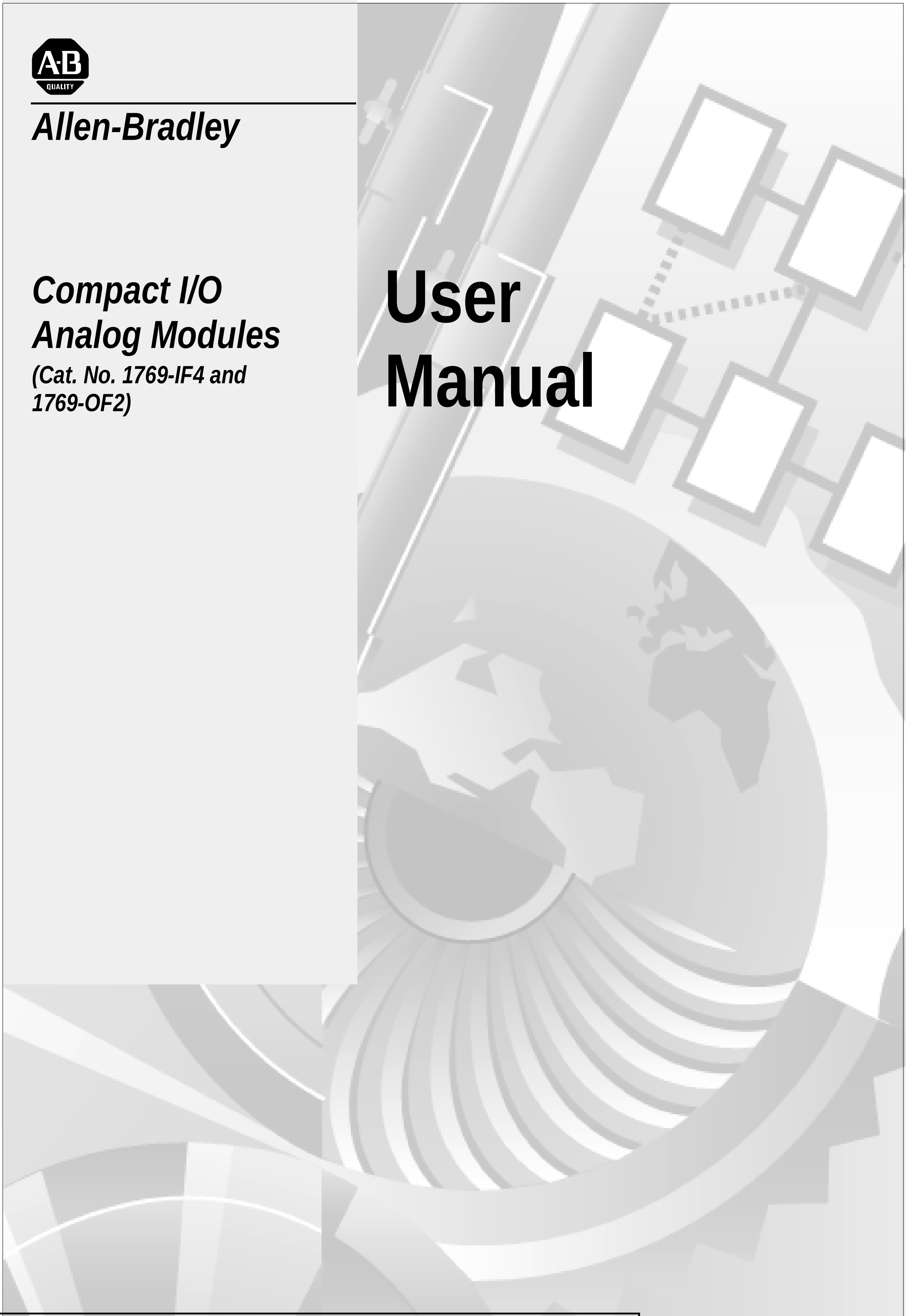
Allen-Bradley

Compact I/O Analog Modules

(Cat. No. 1769-IF4 and 1769-OF2)

User Manual



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Important User Information

Because of the variety of uses for the products described in this publication, those responsible for the application and use of this control equipment must satisfy themselves that all necessary steps have been taken to assure that each application and use meets all performance and safety requirements, including any applicable laws, regulations, codes and standards.

The illustrations, charts, sample programs and layout examples shown in this guide are intended solely for purposes of example. Since there are many variables and requirements associated with any particular installation, Allen-Bradley does not assume responsibility or liability (to include intellectual property liability) for actual use based upon the examples shown in this publication.

Allen-Bradley publication SGI-1.1, *Safety Guidelines for the Application, Installation and Maintenance of Solid-State Control* (available from your local Allen-Bradley office), describes some important differences between solid-state equipment and electromechanical devices that should be taken into consideration when applying products such as those described in this publication.

Throughout this manual we use notes to make you aware of safety considerations:

ATTENTION: Identifies information about practices or circumstances that can lead to personal injury or death, property damage or economic loss.

Attention statements help you to:

- identify a hazard
- avoid a hazard
- recognize the consequences

Important: Identifies information that is critical for successful application and understanding of the product.

Preface

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Read this preface to familiarize yourself with the rest of the manual. This preface covers the following topics:

- who should use this manual
- how to use this manual
- related publications
- conventions used in this manual
- Allen-Bradley support

Who Should Use This Manual

Use this manual if you are responsible for designing, installing, programming, or troubleshooting control systems that use Allen-Bradley Compact I/O and/or Micrologix™ 1500 controllers.

How to Use This Manual

As much as possible, we organized this manual to explain, in a task-by-task manner, how to install, configure, program, operate and troubleshoot a control system using the 1769 analog I/O modules.

Manual Contents

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An overview of the analog input and output modules	Chapter 1
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Definitions of terms used in this manual	Glossary

Related Documentation

The table below provides a listing of publications that contain important information about MicroLogix 1500 systems.

For	Read this document	Document number
A user manual containing information on how to install, use and program your MicroLogix 1500 controller	MicroLogix™ 1500 User Manual	1764-6.1
Installation guides for 1769 Discrete Compact I/O module 1769-IA16	Compact 1769-IA16 120V ac Input Module Installation Instructions	1769-5.1
Installation guides for 1769 Discrete Compact I/O module 1769-OW8	Compact 1769-OW8 AC/DC Relay Output Module Installation Instructions	1769-5.2
Installation guides for 1769 Discrete Compact I/O module 1769-IQ16	Compact 1769-IQ16 24V dc Sink/ Source Input Module Installation Instructions	1769-5.3
Installation guides for 1769 Discrete Compact I/O module 1769-OB16	Compact 1769-OB16 Solid State 24V dc Source Output Module Installation Instructions	1769-5.4
Installation guides for 1769 Discrete Compact I/O module 1769-OA8	Compact 1769-OA8 100 to 240V ac Solid State Output Module Installation Instructions	1769-5.5
Installation guides for 1769 Discrete Compact I/O module 1769-OV16	Compact 1769-OV16 Solid State 24V dc Sink Output Module Installation Instructions	1769-5.6
Installation guides for 1769 Discrete Compact I/O module 1769-IQ6XOW4	Compact 1769-IQ6XOW4 24V dc Sink/ Source Input AC/DC Relay Output Module Installation Instructions	1769-5.7
Installation guides for 1769 Discrete Compact I/O module 1769-IM12	Compact 1769-IM12 240V ac Input Module Installation Instructions	1769-5.8
An overview of 1769 Compact Discrete I/O modules	1769 Compact Discrete Input/Output Modules Product Data	1769-2.1
An overview of 1769 Compact Analog I/O modules	1769 Compact Analog Input/Output Modules Product Data	1769-2.2
In-depth information on grounding and wiring Allen-Bradley programmable controllers.	Allen-Bradley Programmable Controller Grounding and Wiring Guidelines	1770-4.1

If you would like a manual, you can:

- download a free electronic version from the internet at www.theautomationbookstore.com
- purchase a printed manual by:
  - contacting your local distributor or Rockwell Automation representative
  - visiting www.theautomationbookstore.com and placing your order
  - calling 1.800.963.9548 (USA/Canada) or 001.330.725.1574 (Outside USA/Canada)

Conventions Used in This Manual

The following conventions are used throughout this manual:

- Bulleted lists (like this one) provide information not procedural steps.
- Numbered lists provide sequential steps or hierarchical information.
- *Italic* type is used for emphasis.
- Text in this `font` indicates words or phrases you should type.

Allen-Bradley Support

Allen-Bradley offers support services worldwide, with over 75 Sales/Support Offices, 512 authorized distributors and 260 authorized Systems Integrators located throughout the United States alone, plus Allen-Bradley representatives in every major country in the world.

Local Product Support

Contact your local Allen-Bradley representative for:

- sales and order support
- product technical training
- warranty support
- support service agreement

Technical Product Assistance

If you need to contact Allen-Bradley for technical assistance, please review the information in Chapter 6, *Module Diagnostics and Troubleshooting* first. Then call your local Allen-Bradley representative.

Your Questions or Comments on the Manual

If you find a problem with this manual, please notify us using the self-mailer Publications Problem Report in the front of this manual.

If you have any suggestions for how this manual could be made more useful to you, please contact us at the address below:

Allen-Bradley Company, Inc.
Control and Information Group
Technical Communication, Dept. A602V, T122
P.O. Box 2086
Milwaukee, WI 53201-2086

Overview

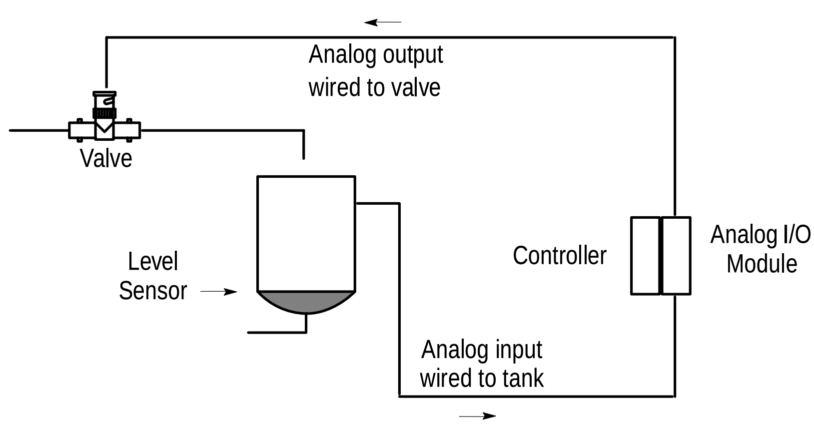
This chapter explains how analog data is used, and describes the 1769-IF4 analog input module and the 1769-OF2 analog output module. Included is information about:

- the use of analog I/O
- the modules’ hardware and diagnostic features
- an overview of the 1769 analog input system operation
- an overview of the 1769 analog output system operation

How to Use Analog I/O

Analog refers to the representation of numerical quantities by the measurement of continuous physical variables. Analog applications are present in many forms. The following application shows a typical use of analog data.

In this application, the processor controls the amount of fluid in a holding tank by adjusting the valve opening. The valve is initially open 100%. As the fluid level in the tank approaches the preset point, the processor modifies the output to close the valve 90%, 80%, and so on, continuously adjusting the valve to maintain the fluid level.



General Description

The 1769-IF4 analog input module converts and digitally stores analog data for retrieval by controllers, such as the MicroLogix™ 1500. The module supports connections from any combination of up to four voltage or current analog sensors. The four high-impedance input channels can be wired as either single-ended or differential inputs.

The 1769-OF2 output module provides two single-ended analog output channels, each individually configurable for voltage or current.

Both modules provide the following input/output types/ranges:

Table: 1.A Normal and Full Ranges

Normal Operating Input Range	Full Module Range
±10V dc	± 10.5V dc
1 to 5V dc	0.5 - 5.25V dc
0 to 5V dc	-0.5 - +5.25V dc
0 to 10V dc	-0.5 - +10.5V dc
0 to 20 mA	0 - 21 mA
4 to 20 mA	3.2 - 21 mA

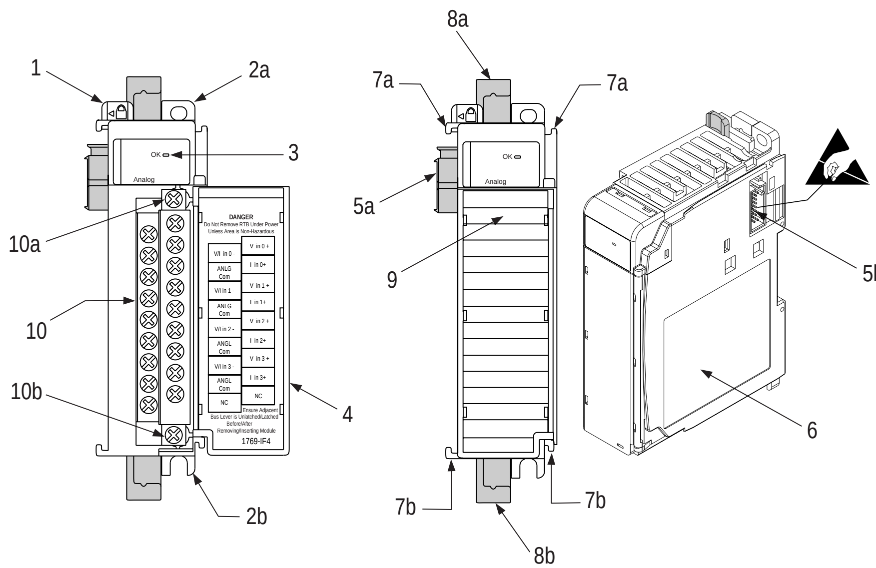
The data can be configured on board each module as:

- Engineering Units
- Scaled-for-PID
- Percent
- Raw/Proportional Data

Hardware Features

The modules contain removable terminal blocks. The 1769-IF4's four channels can be wired as either single-ended or differential inputs. The 1769-OF2's two channels are single-ended only. Module configuration is normally done via the controller's programming software. In addition, some controllers support configuration via the user program. In either case, the module configuration is stored in the memory of the controller. Refer to your controller manual for more information.

The illustration below shows the hardware features of both the 1769-IF4 and the 1769-OF2 modules.



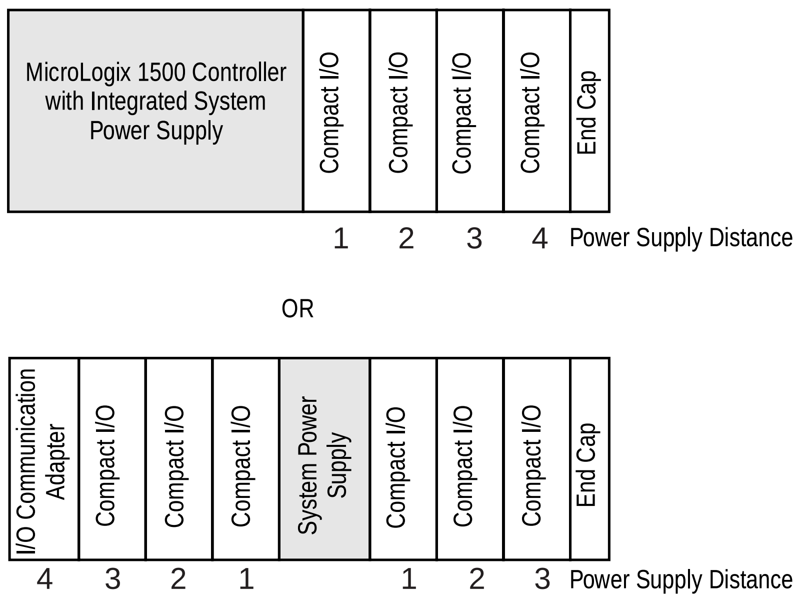
Item	Description
1	bus lever
2a	upper panel mounting tab
2b	lower panel mounting tab
3	Module Status LED
4	module door with terminal identification label
5a	movable bus connector (bus interface) with female pins
5b	stationary bus connector (bus interface) with male pins
6	nameplate label
7a	upper tongue-and-groove slots
7b	lower tongue-and-groove slots
8a	upper DIN rail latch
8b	lower DIN rail latch
9	write-on label for user identification tags
10	removable terminal block (RTB) with finger-safe cover
10a	RTB upper retaining screw
10b	RTB lower retaining screw

General Diagnostic Features

The 1769-IF4 and 1769-OF2 modules contain diagnostic features that can help you identify the source of problems that may occur during power-up or during normal channel operation. These power-up and channel diagnostics are explained in chapter 6, *Module Diagnostics and Troubleshooting.*

System Overview

The modules communicate to the controller through the bus interface. The modules also receive 5 and 24V dc power through the bus interface. You can install as many analog modules as your power supply can support. However, the modules have a power supply distance rating of 8, which means that they may not be located more than 8 modules away from the system power supply.



System Operation

At power-up, the module performs a check of its internal circuits, memory, and basic functions. During this time, the module status LED remains off. If no faults are found during power-up diagnostics, the module status LED is turned on.

After power-up checks are complete, the module waits for valid channel configuration data. If an invalid configuration is detected, the module generates a configuration error. Once a channel is properly configured and enabled, it begins the analog-to-digital or digital-to-analog conversion process.

Input Module

Each time a channel is read by the input module, that analog data value is tested by the module for an over-range or under-range condition. If such a condition is detected, a unique bit is set in the channel status word. The channel status word is described in “1769-IF4 Input Data File” on page 4-2.

The controller reads the two’s complement binary converted analog data from the module. This typically occurs at the end of the program scan or when commanded by the control program. If the controller and the module determine that the bus data transfer was made without error, the data is used in your control program.

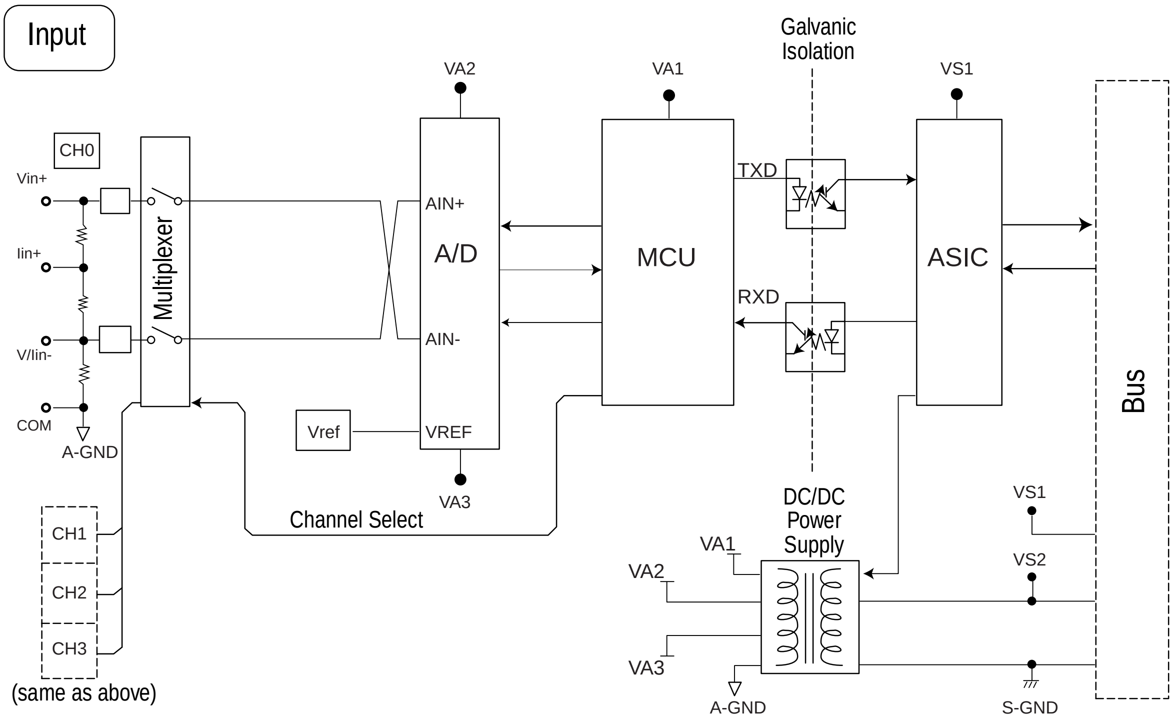
Output Module

The output module monitors channels for over-range and under-range conditions and also for broken output wires and high load resistance (in current mode only). If such a condition is detected, a unique bit is set in the channel status word. The channel status word is described in “1769-OF2 Input Data File” on page 5-2.

The output module receives two’s complement binary values from the bus master. This typically occurs at the end of the program scan or when commanded by the control program. If the controller and the module determine that the bus transfer was completed without error, the output module converts the data to an analog output signal.

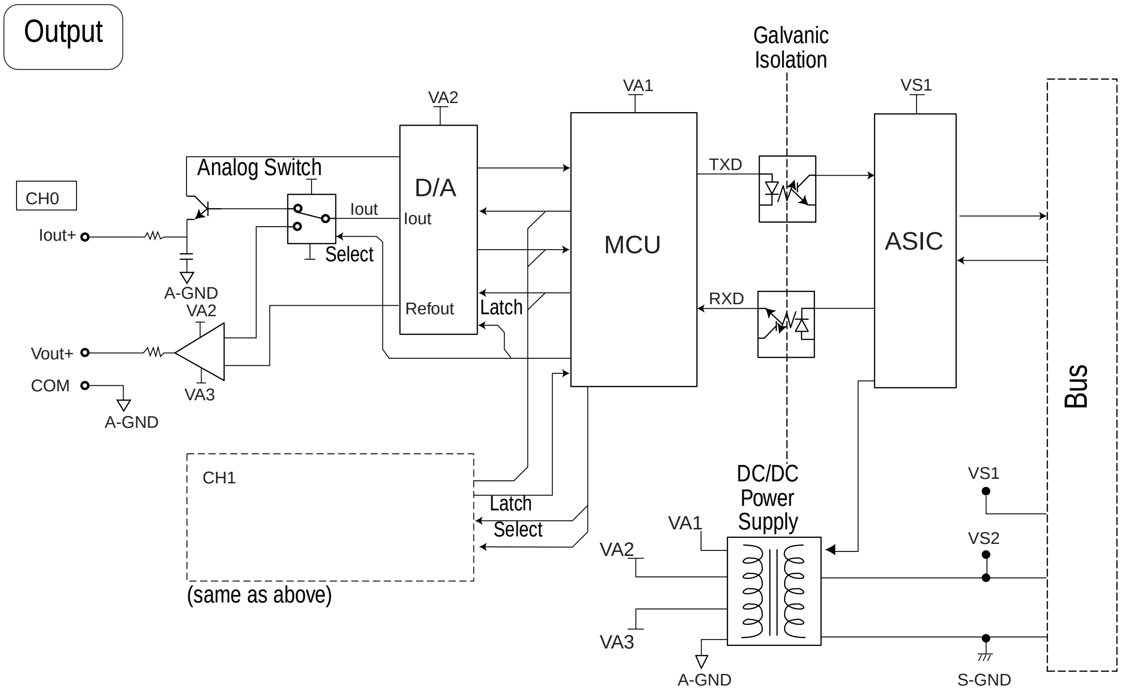
Module Operation

The input module’s input circuitry consists of four differential analog inputs multiplexed into a single analog-to-digital (A/D) converter. The A/D converter reads the selected input signal and converts it to a digital value which is presented to the controller. The multiplexer sequentially switches each input channel to the module’s A/D converter. See the block diagram below.



The output module uses a digital-to-analog (D/A) converter to read the digital output data from the controller and convert it to an analog output signal. See the block diagram below.

Output



Module Field Calibration

The 1769-IF4 input module performs autocalibration when a channel is initially enabled. In addition, if a channel is configured differently than the previously scanned channel, an autocalibration cycle is run as part of the reconfiguration process.

The 1769-OF2 output module's calibration is guaranteed by its design. No field calibration is required.

Quick Start for Experienced Users

Before You Begin

This chapter can help you to get started using the analog modules. We base the procedures here on the assumption that you have an understanding of Allen-Bradley controllers. You should understand electronic process control and be able to interpret the ladder logic instructions required to generate the electronic signals that control your application.

Because it is a start-up guide for experienced users, this chapter *does not* contain detailed explanations about the procedures listed. It does, however, reference other chapters in this book where you can get more information about applying the procedures described in each step. It also references other documentation that may be helpful if you are unfamiliar with programming techniques or system installation requirements.

If you have any questions or are unfamiliar with the terms used or concepts presented in the procedural steps, *always read the referenced chapters* and other recommended documentation before trying to apply the information.

Required Tools and Equipment

Have the following tools and equipment ready:

- medium blade or cross-head screwdriver
- analog input or output device
- shielded, twisted-pair cable for wiring (Belden™ 8761 or equivalent)
- controller
  (for example, a MicroLogix™ 1500 controller)
- analog input or output module
- programming device and software
  (for example, RSLogix 500™)

What You Need To Do

This chapter covers:

- Ensuring that your power supply is adequate
- Attaching and locking the module
- Wiring the module
- Configuring the module
- Going through the startup procedure
- Monitoring module operation

Step 1: Ensure that your power supply has sufficient current output to support your system configuration.

Reference: Chapter 3 (Installation and Wiring)

The modules maximum current draw is shown below.

Module	5V dc	24V dc
1769-IF4	120 mA	150 mA
1769-OF2	120 mA	200 mA

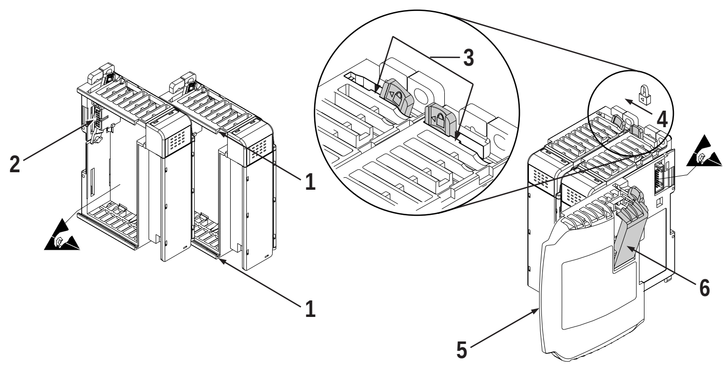
Note: The module may not be located more than 8 modules away from the system power supply.

Step 2: Attach and lock the module.

Reference: Chapter 3 (Installation and Wiring)

Note: The modules can be panel or DIN rail mounted. Modules can be assembled before or after mounting.

ATTENTION: Remove power before removing or inserting this module. When you remove or insert a module with power applied, an electrical arc may occur.



1. Check that the bus lever of the module to be installed is in the unlocked (fully right) position.

2. Use the upper and lower tongue-and-groove slots (1) to secure the modules together (or to a controller).

3. Move the module back along the tongue-and-groove slots until the bus connectors (2) line up with each other.

4. Push the bus lever back slightly to clear the positioning tab (3). Use your fingers or a small screw driver.

5. To allow communication between the controller and module, move the bus lever fully to the left (4) until it clicks. Ensure it is locked firmly in place.

> **ATTENTION:** When attaching I/O modules, it is very important that the bus connectors are securely locked together to ensure proper electrical connection.

6. Attach an end cap terminator (5) to the last module in the system by using the tongue-and-groove slots as before.

7. Lock the end cap bus terminator (6).

Step 3: Wire the module.

Reference: Chapter 3 (Installation and Wiring)

Follow the guidelines below when wiring the module.

General

- All module commons (ANLG COM) are connected in the analog module. The analog common (ANLG COM) is not connected to earth ground inside the module.
- Channels are not isolated from one another.
- Do not use the analog module's NC terminals as connection points.
- Keep shield connection to ground as short as possible.
- To ensure optimum accuracy, limit overall cable impedance by keeping your cable as short as possible. Locate the I/O system as close to your sensors or actuators as your application will permit.
- Use Belden™ 8761, or equivalent, shielded connection wire.

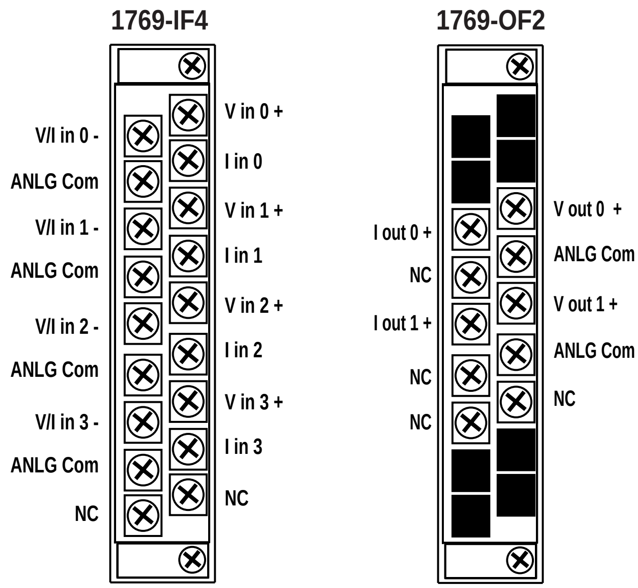
1769-IF4 Input Module

- If multiple power supplies are used with analog inputs, the power supply commons must be connected.
- The 1769-IF4 module does not provide loop power for analog inputs. Use a power supply that matches the input transmitter specifications.
- Differential analog inputs are more immune to noise than single-ended analog inputs.
- Voltages on Vin+, V/Iin-, and Iin+ of the 1769-IF4 module must be within ±10V dc of analog common.

1769-OF2 Output Module

- Voltage outputs (Vout 0+ and Vout 1+) of the 1769-OF2 module are referenced to ANLG COM. Load resistance for a voltage output channel must be equal to or greater than 2K Ω .
- Current outputs (Iout 0+ and Iout 1+) of the 1769-OF2 module source current that returns to ANLG COM. Load resistance for a current output channel must remain between 0 and 500 Ω .

The terminal connections are shown below:



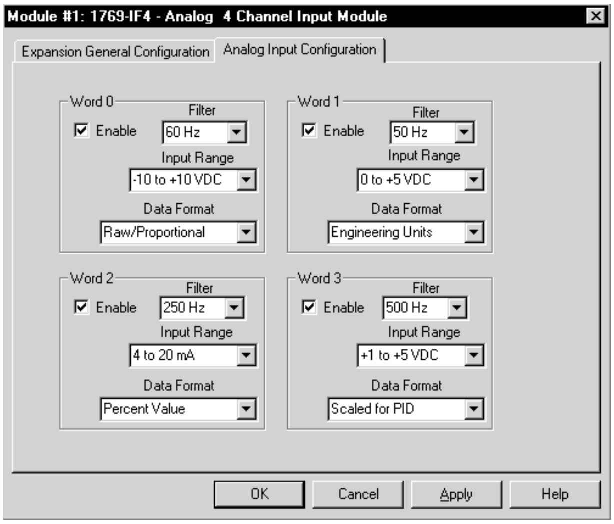
See “1769-IF4 Analog Input Wiring” on page 3-14 for examples of wiring using differential and single-ended inputs. See“1769-OF2 Analog Output Wiring” on page 3-16 for more information on output module wiring.

Step 4: Configure the module.

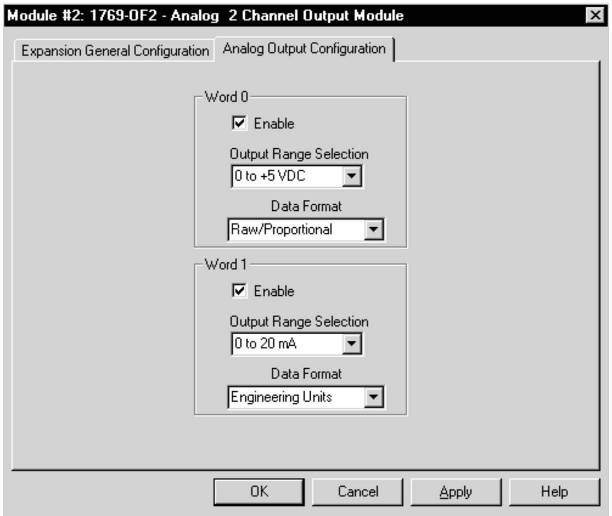
Reference: Chapter 4 (Module Data, Status, and Channel Configuration for 1769-IF4)
Chapter 5 (Module Data, Status, and Channel Configuration for 1769-OF2)

The configuration file is typically modified using the programming software configuration screen as shown below. It can also be modified through the control program, if supported by the controller. See the configuration file chart on page 4-5 for 1769-IF4 and page 5-6 for 1769-OF2.

1769-IF4 Configuration Screen in RSLogix500™



1769-OF2 Configuration Screen in RSLogix500™



Note: The configuration default is to enable an analog channel. For improved system performance, especially for analog inputs, disable any *unused* channels.

Step 5: Go through the startup procedure.

Reference: Chapter 6 (Module Diagnostics and Troubleshooting)

1. Apply power.

2. Download your program, which contains the analog module configuration settings, to the controller and put the controller into Run mode.

3. During a normal start-up, the module status LED turns on.

4. If the module status LED does not turn on, cycle power. If the condition persists, contact your local distributor or Allen-Bradley for assistance.

5. Module and channel configuration errors are reported to the controller. These errors are typically reported in the controller's I/O status file. Check the controller's I/O status file.

Step 6: Monitor the module status to check if the module is operating correctly.

Reference: Chapter 6 (Module Diagnostics and Troubleshooting)

Module and channel configuration errors are reported to the controller. These errors are typically reported in the controller's I/O status file.

Channel status data is also reported in the module's input data table, so these bits can be used in your control program to flag a channel error.

1769-IF4 Input Data Table

Word	Bit Position															
	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	SGN	Analog Input Data Channel 0														
1	SGN	Analog Input Data Channel 1														
2	SGN	Analog Input Data Channel 2														
3	SGN	Analog Input Data Channel 3														
4	Not Used												S3	S2	S1	S0
5	U0	O0	U1	01	U2	O2	U3	O3	Set to 0							

1769-OF2 Input Data Table

Word	Bit Position															
	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	D0	H0	D1	H1	Not Used (Bits set to 0)										S1	S0
1	U0	O0	U1	O1	Bits set to 0											
2	SGN	Output Data Loopback/Echo Channel 0														
3	SGN	Output Data Loopback/Echo Channel 1														

The bit definitions are as follows:

- Dx = Diagnostic bits. When set, they indicate a broken output wire or high load resistance (not used on voltage outputs).
- Hx = Hold Last State bits. When set, they indicate that the channel is in a hold last state condition.
- Sx = General Status bits. When set, these bits indicate an error (over-range, under-range, or diagnostic bit) associated with that channel or a module hardware error.
- Ux = Under-range flag bits.
- Ox = Over-range flag bits.
- SGN = Sign bit in two's complement format.

Installation and Wiring

This chapter tells you how to:

- determine the power requirements for the modules
- avoid electrostatic damage
- install the module
- wire the module's terminal block
- wire input devices
- wire output devices

Compliance to European Union Directives

This product is approved for installation within the European Union and EEA regions. It has been designed and tested to meet the following directives.

EMC Directive

The analog modules are tested to meet Council Directive 89/336/EEC Electromagnetic Compatibility (EMC) and the following standards, in whole or in part, documented in a technical construction file:

- EN 50081-2
  EMC - Generic Emission Standard, Part 2 - Industrial Environment
- EN 50082-2
  EMC - Generic Immunity Standard, Part 2 - Industrial Environment

This product is intended for use in an industrial environment.

Low Voltage Directive

This product is tested to meet Council Directive 73/23/EEC Low Voltage, by applying the safety requirements of EN 61131-2 Programmable Controllers, Part 2 – Equipment Requirements and Tests.

For specific information required by EN61131-2, see the appropriate sections in this publication, as well as the following Allen-Bradley publications:

- Industrial Automation, Wiring and Grounding Guidelines for Noise Immunity, publication 1770-4.1
- Automation Systems Catalog, publication B111

Power Requirements

The modules receive power through the bus interface from the +5V dc/+24V dc system power supply. The maximum current drawn by the modules is shown in the table below.

Module	5V dc	24V dc
1769-IF4	120 mA	150 mA
1769-OF2	120 mA	200 mA

Module Installation

Compact I/O is suitable for use in an industrial environment when installed in accordance with these instructions. Specifically, this equipment is intended for use in clean, dry environments (Pollution degree 2[1]) and to circuits not exceeding Over Voltage Category II[2] (IEC 60664-1).[3]

Prevent Electrostatic Discharge

ATTENTION: Electrostatic discharge can damage integrated circuits or semiconductors if you touch analog I/O module bus connector pins or the terminal block on the input module. Follow these guidelines when you handle the module:

- Touch a grounded object to discharge static potential.
- Wear an approved wrist-strap grounding device.
- Do not touch the bus connector or connector pins.
- Do not touch circuit components inside the module.
- If available, use a static-safe work station.
- When it is not in use, keep the module in its static-shield box.

1. Pollution Degree 2 is an environment where, normally, only non-conductive pollution occurs except that occasionally a temporary conductivity caused by condensation shall be expected.
2. Over Voltage Category II is the load level section of the electrical distribution system. At this level transient voltages are controlled and do not exceed the impulse voltage capability of the product's insulation.
3. Pollution Degree 2 and Over Voltage Category II are International Electrotechnical Commission (IEC) designations.

Remove Power

ATTENTION: Remove power before removing or inserting this module. When you remove or insert a module with power applied, an electrical arc may occur. An electrical arc can cause personal injury or property damage by:

- sending an erroneous signal to your system's field devices, causing unintended machine motion
- causing an explosion in a hazardous environment
- Electrical arcing causes excessive wear to contacts on both the module and its mating connector and may lead to premature failure.

General Considerations

Reducing Noise

Most applications require installation in an industrial enclosure to reduce the effects of electrical interference. Analog inputs and outputs are highly susceptible to electrical noise. Electrical noise coupled to the analog inputs will reduce the performance (accuracy) of the module.

Group your modules to minimize adverse effects from radiated electrical noise and heat. Consider the following conditions when selecting a location for the analog module. Position the module:

- away from sources of electrical noise such as hard-contact switches, relays, and AC motor drives
- away from modules which generate significant radiated heat, such as the 1769-IA16. Refer to the module's heat dissipation specification.

In addition, route shielded, twisted-pair analog input and output wiring away from any high voltage I/O wiring.

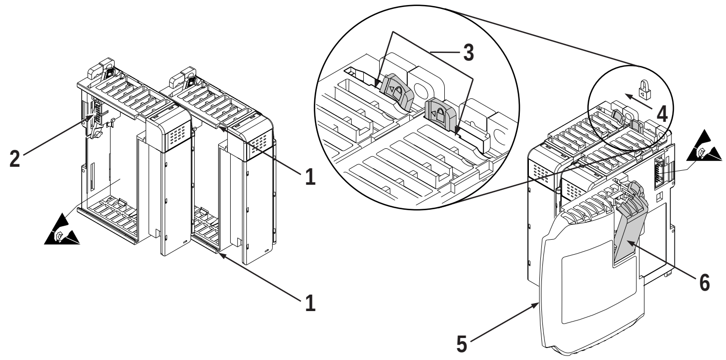
Protecting the Circuit Board from Contamination

The printed circuit boards of the analog modules must be protected from dirt, oil, moisture, and other airborne contaminants. To protect these boards, the system must be installed in an enclosure suitable for the environment. The interior of the enclosure should be kept clean and the enclosure door should be kept closed whenever possible.

System Assembly

The module can be attached to the controller or an adjacent I/O module *before* or *after* mounting. For mounting instructions, see "Panel Mounting Using the Dimensional Template" on page 3-5, or "DIN Rail Mounting" on page 3-6. To work with a system that is already mounted, see "Replacing a Single Module within a System" on page 3-7.

The following procedure shows you how to assemble the Compact I/O system.



1. Disconnect power.

2. Check that the bus lever of the module to be installed is in the unlocked (fully right) position.

3. Use the upper and lower tongue-and-groove slots (1) to secure the modules together (or to a controller).

4. Move the module back along the tongue-and-groove slots until the bus connectors (2) line up with each other.

5. Push the bus lever back slightly to clear the positioning tab (3). Use your fingers or a small screw driver.

6. To allow communication between the controller and module, move the bus lever fully to the left (4) until it clicks. Ensure it is locked firmly in place.

ATTENTION: When attaching I/O modules, it is very important that the bus connectors are securely locked together to ensure proper electrical connection.

7. Attach an end cap terminator (5) to the last module in the system by using the tongue-and-groove slots as before.

8. Lock the end cap bus terminator (6).

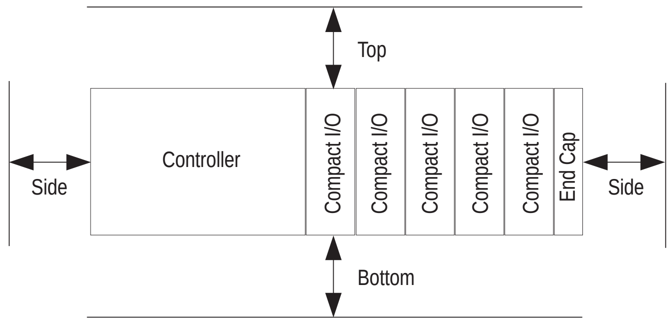
Important: A 1769-ECR or 1769-ECL right or left end cap must be used to terminate the end of the bus.

Mounting

ATTENTION: During panel or DIN rail mounting of all devices, be sure that all debris (metal chips, wire strands, etc.) is kept from falling into the module. Debris that falls into the module could cause damage at power up.

Minimum Spacing

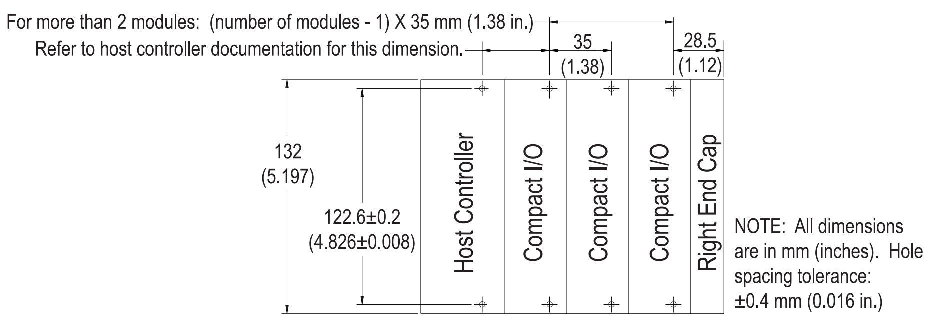
Maintain spacing from enclosure walls, wireways, adjacent equipment, etc. Allow 50 mm (2 in.) of space on all sides for adequate ventilation, as shown below:



Panel Mounting

Mount the module to a panel using two screws per module. Use M4 or #8 panhead screws. Mounting screws are required on every module.

Panel Mounting Using the Dimensional Template



Panel Mounting Procedure Using Modules as a Template

The following procedure allows you to use the assembled modules as a template for drilling holes in the panel. If you have sophisticated panel mounting equipment, you can use the dimensional template provided on page 3-5. Due to module mounting hole tolerance, it is important to follow these procedures:

1. On a clean work surface, assemble no more than three modules.
2. Using the assembled modules as a template, carefully mark the center of all module-mounting holes on the panel.
3. Return the assembled modules to the clean work surface, including any previously mounted modules.
4. Drill and tap the mounting holes for the recommended M4 or #8 screw.
5. Place the modules back on the panel, and check for proper hole alignment.
6. Attach the modules to the panel using the mounting screws.

   Note: If mounting more modules, mount only the last one of this group and put the others aside. This reduces remounting time during drilling and tapping of the next group.

7. Repeat steps 1 to 6 for any remaining modules.

DIN Rail Mounting

The module can be mounted using the following DIN rails:
35 x 7.5 mm (EN 50 022 - 35 x 7.5) or 35 x 15 mm
(EN 50 022 - 35 x 15).

Before mounting the module on a DIN rail, close the DIN rail latches. Press the DIN rail mounting area of the module against the DIN rail. The latches will momentarily open and lock into place.

Replacing a Single Module within a System

The module can be replaced while the system is mounted to a panel (or DIN rail).

1. Remove power. See important note on page 3-3.
2. On the module to be removed, remove the upper and lower mounting screws from the module (or open the DIN latches using a flat-blade or phillips-style screw driver).
3. Move the bus lever to the right to disconnect (unlock) the bus.
4. On the right-side adjacent module, move its bus lever to the right (unlock) to disconnect it from the module to be removed.
5. Gently slide the disconnected module forward. If you feel excessive resistance, check that the module has been disconnected from the bus, and that both mounting screws have been removed (or DIN latches opened).

   Note: It may be necessary to rock the module slightly from front to back to remove it, or, in a panel-mounted system, to loosen the screws of adjacent modules.

6. Before installing the replacement module, be sure that the bus lever on the module to be installed, and on the right-side adjacent module are in the unlocked (fully right) position.
7. Slide the replacement module into the open slot.
8. Connect the modules together by locking (fully left) the bus levers on the replacement module and the right-side adjacent module.
9. Replace the mounting screws (or snap the module onto the DIN rail).

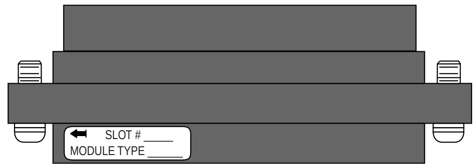
Field Wiring Connections

Grounding

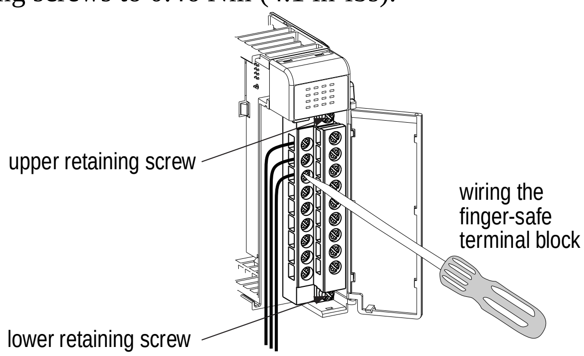
This product is intended to be mounted to a well-grounded mounting surface such as a metal panel. Additional grounding connections from the module's mounting tabs or DIN rail (if used) are not required unless the mounting surface cannot be grounded. Refer to *Industrial Automation Wiring and Grounding Guidelines*, Allen-Bradley publication 1770-4.1, for additional information.

Removing the Finger-Safe Terminal Block

When installing the module, it is not necessary to remove the terminal block. If you remove the terminal block, use the write-on label located on the side of the terminal block to identify the module location and type.



To remove the terminal block, loosen the upper and lower retaining screws. The terminal block will back away from the module as you remove the screws. When replacing the terminal block, torque the retaining screws to 0.46 Nm (4.1 in-lbs).



Wiring the Finger-Safe Terminal Block

When wiring the terminal block, keep the finger-safe cover in place.

1. Loosen the terminal screws to be wired.
2. Route the wire under the terminal pressure plate. You can use the bare wire or a spade lug. The terminals accept a 6.35 mm (0.25 in.) spade lug.
3. Tighten the terminal screw making sure the pressure plate secures the wire. Recommended torque when tightening terminal screws is 0.68 Nm (6 in-lbs).

Note: If you need to remove the finger-safe cover, insert a screw driver into one of the square, wiring holes and gently pry the cover off. If you wire the terminal block with the finger-safe cover removed, you will not be able to put it back on the terminal block because the wires will be in the way.

Wire Size and Terminal Screw Torque

Each terminal accepts up to two wires with the following restrictions:

Wire Type		Wire Size	Terminal Screw Torque	Retaining Screw Torque
Solid	Cu-90°C (194°F)	#14 to #22 AWG	0.68 Nm (6 in-lbs)	0.46 Nm (4.1 in-lbs)
Stranded	Cu-90°C (194°F)	#16 to #22 AWG	0.68 Nm (6 in-lbs)	0.46 Nm (4.1 in-lbs)

System Wiring Guidelines

Consider the following when wiring your system:

General

- All module commons (ANLG COM) are connected in the analog module. The analog common (ANLG COM) is not connected to earth ground inside the module.
- Do not use the analog module’s NC terminals as connection points.
- Channels are not isolated from each other.
- Keep shield connection to ground as short as possible.
- To ensure optimum accuracy, limit overall cable impedance by keeping your cable as short as possible. Locate the I/O system as close to your sensors or actuators as your application will permit.
- Use Belden™ 8761, or equivalent, shielded wire.

1769-IF4 Input Module

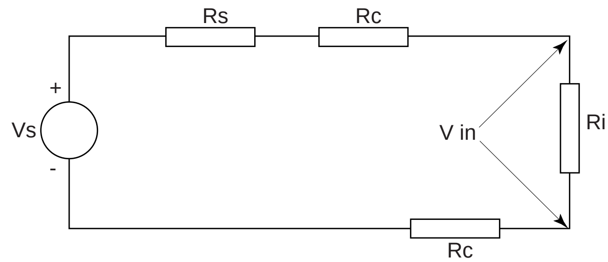
- If multiple power supplies are used with analog inputs, the power supply commons must be connected.
- The 1769-IF4 module does not provide loop power for analog inputs. Use a power supply that matches the input transmitter specifications.
- Differential analog inputs are more immune to noise than single-ended analog inputs.
- Voltages on Vin+, V/Iin-, and Iin+ of the 1769-IF4 module must be within ±10V dc of analog common.

1769-OF2 Output Module

- Voltage outputs (Vout 0+ and Vout 1+) of the 1769-OF2 module are referenced to ANLG COM. Load resistance for a voltage output channel must be equal to or greater than 2K Ω .
- Current outputs (Iout 0+ and Iout 1+) of the 1769-OF2 module source current that returns to ANLG COM. Load resistance for a current output channel must remain between 0 and 500 Ω .

Effect of Transducer/Sensor and Cable Length Impedance on Voltage Input Accuracy

For voltage inputs, the length of the cable used between the transducer/sensor and the 1769-IF4 module can affect the accuracy of the data provided by the module.



Where: Rc = DC resistance of the cable (each conductor) depending on cable length

Rs = Source impedance of analog transducer/sensor input

Ri = Impedance of the voltage input (220 KΩ for 1769-IF4)

Vs = Voltage source (voltage at the transducer/sensor input device)

Vin = Measured potential at the module input

%Ai = Percent added inaccuracy in a voltage-based system due to source and cable impedance.

$$Vin = \frac{[Ri \times Vs]}{[Rs + (2 \times Rc) + Ri]}$$

For example, for Belden 8761 two conductor, shielded cable:

Rc = 16 Ω/1000 ft
Rs = 0 (ideal source)

$$\%Ai = \left(1 - \frac{Vin}{Vs}\right) \times 100$$

Table: 3.1 Effect of Cable Length on Input Accuracy

Length of Cable (m)	dc resistance of the cable, Rc (Ω)	Accuracy impact at the input module
50	2.625	0.00238%
100	5.25	0.00477%
200	10.50	0.00954%
300	15.75	0.0143%

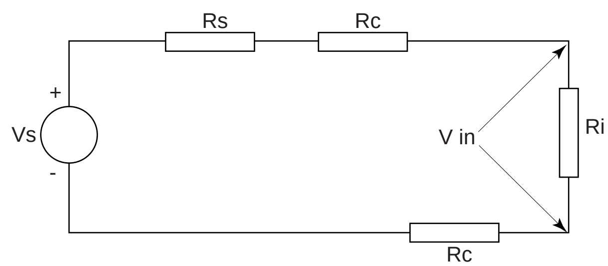
As input source impedance (Rs) and/or resistance (dc) of the cable (Rc) get larger, system accuracy decreases. If you determine that the inaccuracy error is significant, implementing the following equation in the control program can compensate for the added inaccuracy error due to the impedance of the source and cable.

$$Vs = Vin \times \frac{[Rs + (2 \times Rc) + Ri]}{Ri}$$

Note: In a current loop system, source and cable impedance do not impact system accuracy.

Effect of Device and Cable Output Impedance on Output Module Accuracy

The maximum value of the output impedance is shown in the example below, because it creates the largest deviation from an ideal voltage source.



Where: Rc = DC resistance of the cable (each conductor) depending on cable length

Rs = Source impedance of 1769-OF2 (15 Ω)

Ri = Impedance of the voltage input (220 KΩ for 1769-IF4)

Vs = Voltage at the output of 1769-OF2

Vin = Measured potential at the module input

%Ai = Percent added inaccuracy in a voltage-based system due to source and cable impedance.

$$Vin = \frac{[Ri \times Vs]}{[Rs + (2 \times Rc) + Ri]}$$

For example, for Belden 8761 two conductor, shielded cable and a 1769-IF4 input module:

Rc = 16 Ω/1000 ft
Rs = 15 Ω
Ri = 220.25 KΩ

$$\%Ai = \left(1 - \frac{Vin}{Vs}\right) \times 100$$

Table: 3.2 Effect of Output Impedance and Cable Length on Accuracy

Length of Cable (m)	dc resistance of the cable, Rc (Ω)	Accuracy impact at the input module
50	2.625	0.00919%
100	5.25	0.01157%
200	10.50	0.01634%
300	15.75	0.02111%

As output impedance (Rs) and/or resistance (dc) of the cable (Rc) get larger, system accuracy decreases. If you determine that the inaccuracy error is significant, implementing the following equation in the control program can compensate for the added inaccuracy error due to the impedance of the output module and cable.

$$Vs = Vin \times \frac{[Rs + (2 \times Rc) + Ri]}{Ri}$$

Note: In a current loop system, source and cable impedance do not impact system accuracy.

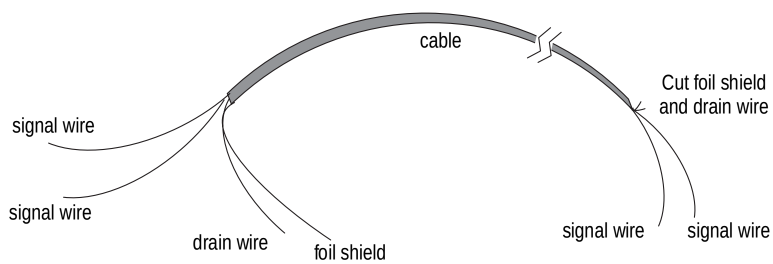
Wiring the Modules

ATTENTION: To prevent shock hazard, care should be taken when wiring the module to analog signal sources. Before wiring any analog module, disconnect power from the system power supply and from any other source to the analog module.

After the analog module is properly installed, follow the wiring procedure below. To ensure proper operation and high immunity to electrical noise, always use Belden™ 8761 (shielded, twisted pair) or equivalent wire.

ATTENTION: When wiring an analog input, take care to avoid connecting a voltage source to a channel configured for current input. Improper module operation or damage to the voltage source can occur.

ATTENTION: Never connect a voltage or current source to an analog output channel.



To wire your module follow these steps.

1. At each end of the cable, strip some casing to expose the individual wires.

2. Trim the signal wires to 2-inch lengths. Strip about 3/16 inch (5 mm) of insulation away to expose the end of the wire.

ATTENTION: Be careful when stripping wires. Wire fragments that fall into a module could cause damage at power up.

3. At one end of the cable, twist the drain wire and foil shield together.

   Under normal conditions, this drain wire and shield junction should be connected to earth ground, via a panel or DIN rail mounting screw at the analog I/O module end. Keep the length of the drain wire as short as possible.

   In environments where high frequency noise may be present, it may be necessary to ground the cable shields to earth at the module end via a 0.1 µF capacitor at the sensor end for analog inputs and at the load end for analog outputs.

4. At the other end of the cable, cut the drain wire and foil shield back to the cable.

5. Connect the signal wires to the terminal block as shown in "1769-IF4 Analog Input Wiring" on page 3-14 and "1769-OF2 Analog Output Wiring" on page 3-16. Connect the other end of the cable to the analog input or output device.

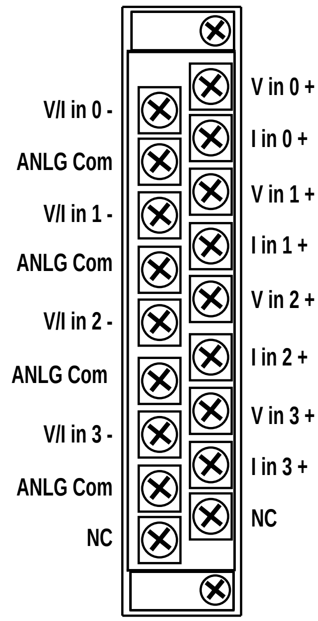
6. Repeat steps 1 through 5 for each channel on the module.

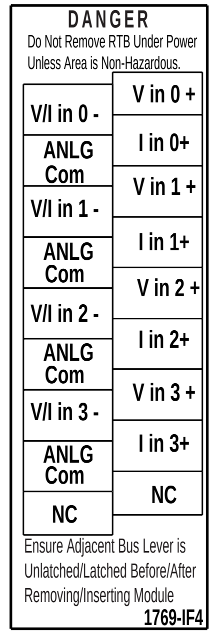
Terminal Door Label

A removable, write-on label is provided with the module. Remove the label from the door, mark the identification of each terminal with permanent ink, and slide the label back into the door. Your markings (ID tag) will be visible when the module door is closed.

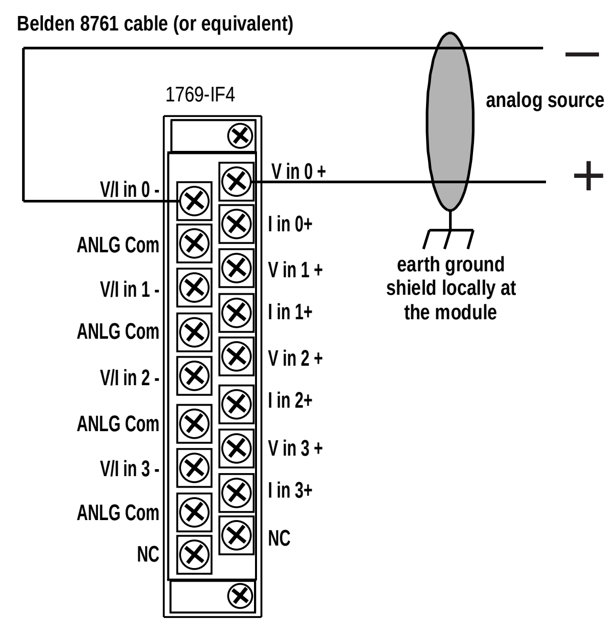
1769-IF4 Analog Input Wiring

Terminal Layout

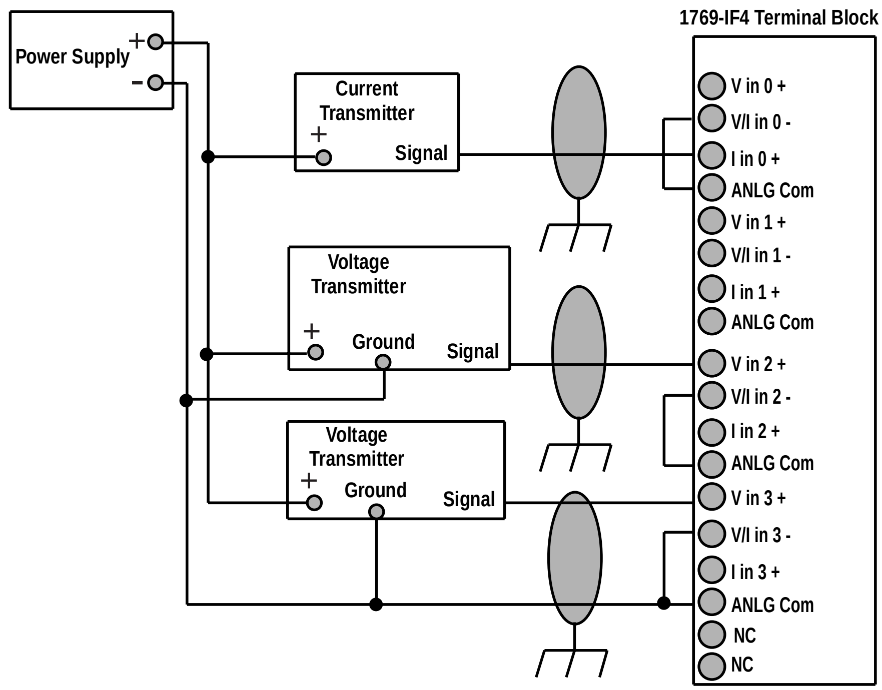




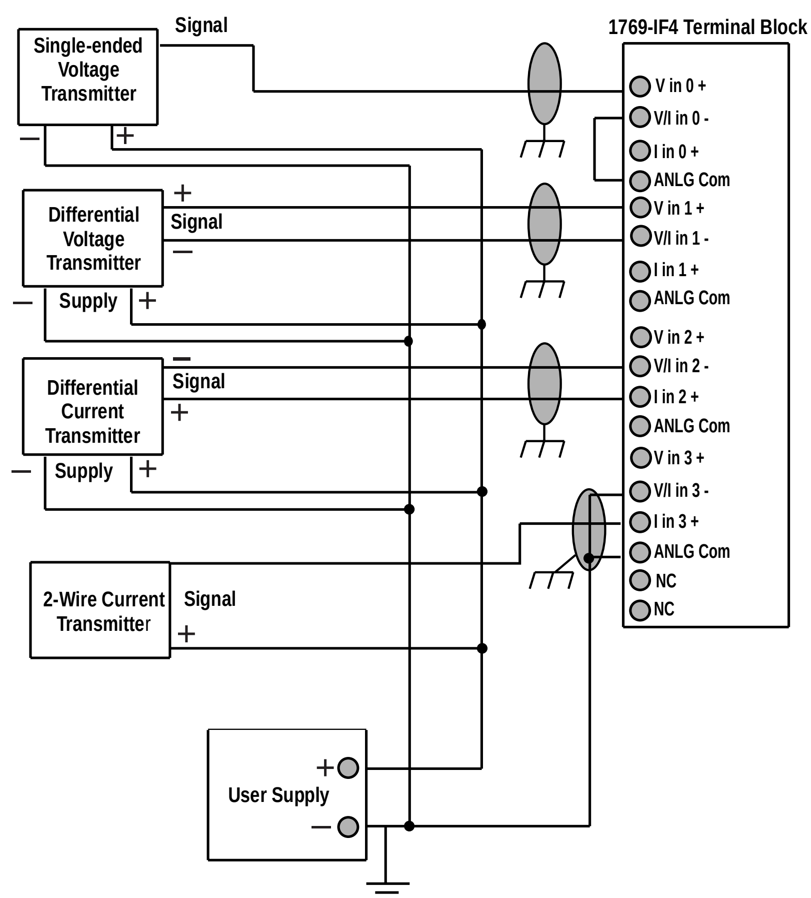
Wiring Diagram Showing Differential Inputs



Wiring Single-ended Sensor/Transmitter Types

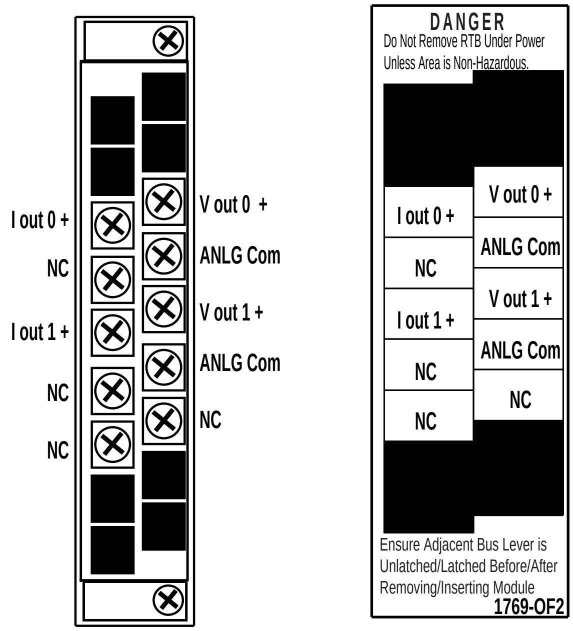


Wiring Mixed Transmitter Types

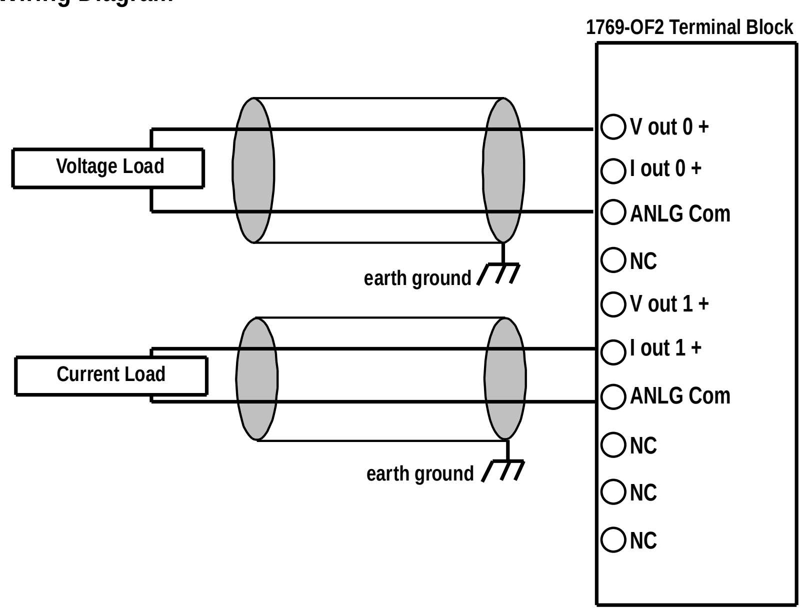


1769-OF2 Analog Output Wiring

Terminal Layout



Wiring Diagram

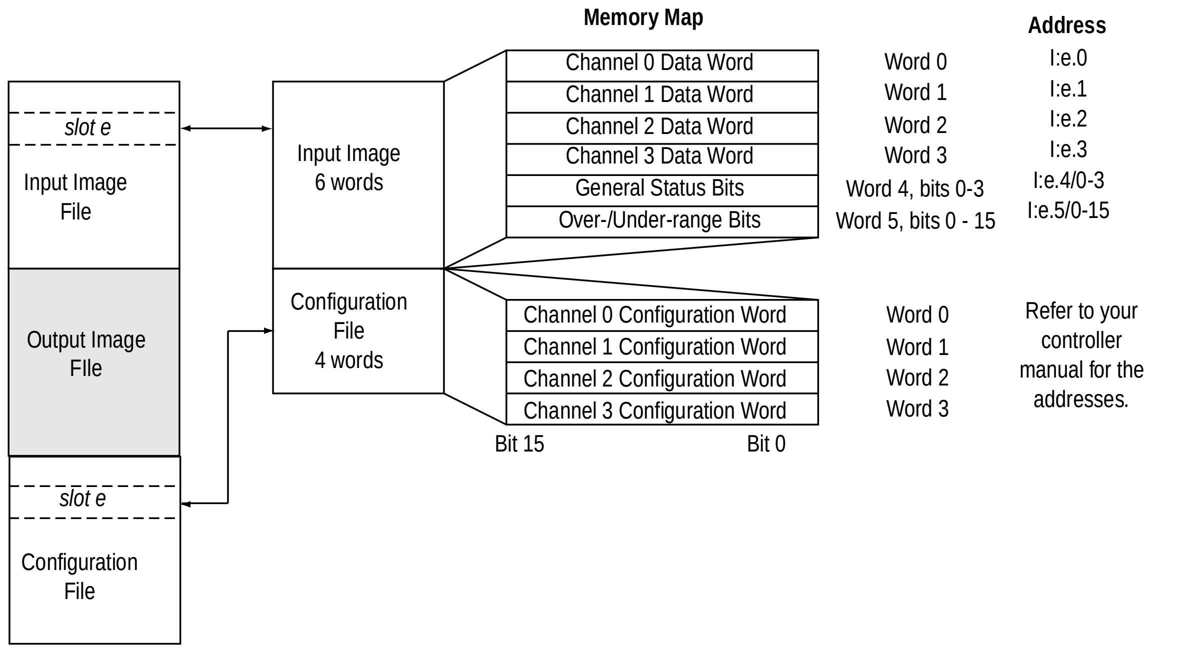


Module Data, Status, and Channel Configuration for 1769-IF4

This chapter examines the analog input module's data table, channel status, and channel configuration word.

Input Module Addressing

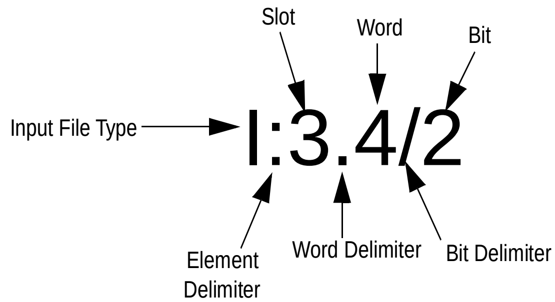
The following memory map shows the input and configuration image tables for the 1769-IF4. Detailed information on the input image table can be found in "1769-IF4 Input Data File" on page 4-2.



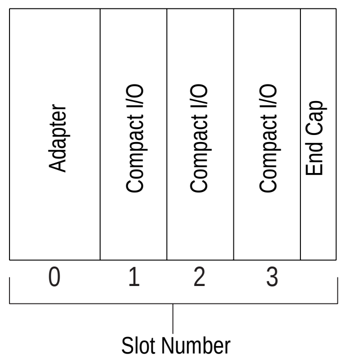
1769-IF4 Input Image

The 1769-IF4 input image file represents data words and status bits. Input words 0 through 3 hold the input data that represents the value of the analog inputs for channels 0 through 3. These data words are valid only when the channel is enabled and there are no errors. Input words 4 and 5 hold the status bits. To receive valid status information, the channel must be enabled.

For example, to obtain the general status of channel 2 of the analog module located in slot 3, use address I:3.4/2.



Note: This addressing scheme is applicable only for the MicroLogix™ 1500 controller.



Note: The end cap does not use a slot address.

1769-IF4 Configuration File

The configuration file contains information that you use to define the way a specific channel functions. The configuration file is explained in more detail in “1769-IF4 Configuration Data File” on page 4-3.

Note: Not all controllers support program access to the configuration file. Refer to your controller’s user manual.

1769-IF4 Input Data File

The input data table allows you to access analog input module read data for use in the control program, via word and bit access. The data table structure is shown in table below.

Table: 4.1 1769-IF4 Input Data Table

Word/Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Word 0	SGN	Analog Input Data Value Channel 0														
Word 1	SGN	Analog Input Data Value Channel 1														
Word 2	SGN	Analog Input Data Value Channel 2														
Word 3	SGN	Analog Input Data Value Channel 3														
Word 4	Not Used (Bits set to 0)												S3	S2	S1	S0
Word 5	U0	O0	U1	O1	U2	O2	U3	O3	Set to zero							

1769-IF4 Input Data Values

Words 0 through 3 contain the converted analog input data from the field device. The most significant bit (MSB) is the sign bit.

General Status Bits (S0 - S3)

Word 4, bits 0 through 3 contain the general operational status bits for input channels 0 through 3. If set (1), these bits indicate an error associated with that channel. The over- and under-range bits for channels 0 through 3 are logically ORed to the appropriate general status bit.

Over-Range Flag Bits (O0 - O3)

Over-range bits for channels 3 through 0 are contained in word 5, bits 8, 10, 12, and 14. They apply to all input types. When set (1), this bit indicates input signals beyond the normal operating range. However, the module continues to convert analog data to the maximum full range value. The bit is automatically reset (0) by the module when the over-range condition is cleared and the data value is within the normal operating range.

Under-Range Flag Bits (U0 - U3)

Under-range bits for channels 3 through 0 are contained in word 5, bits 9, 11, 13, and 15. They apply to all input types. When set (1), this bit indicates input signals below the normal operating range. It may also indicate an open circuit condition, when the module is configured for the 4 - 20 mA range. However, the module continues to convert analog data to the minimum full range value. The bit is automatically reset (0) by the module when the under-range condition is cleared and the data value is within the normal operating range.

1769-IF4 Configuration Data File

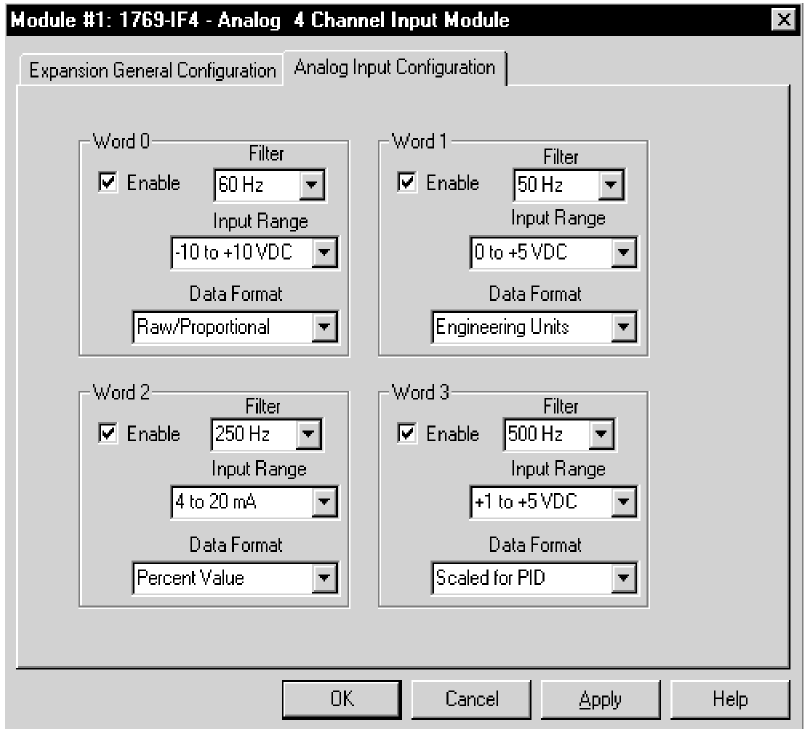
The configuration file allows you to determine how each individual input channel will operate. Parameters such as the input type and data format are set up using this file. This data file is writable and readable. The default value of the configuration data table is all zeros. The structure of the channel configuration file is shown below.

Table: 4.2 1769-IF4 Configuration Data Table[1]

Word/Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Word 0	Enable Channel 0	Input Data Format Select Channel 0			Input Type/Range Select Channel 0				Reserved				Input Filter Select Channel 0			
Word 1	Enable Channel 1	Input Data Format Select Channel 1			Input Type/Range Select Channel 1				Reserved				Input Filter Select Channel 1			
Word 2	Enable Channel 2	Input Data Format Select Channel 2			Input Type/Range Select Channel 2				Reserved				Input Filter Select Channel 2			
Word 3	Enable Channel 3	Input Data Format Select Channel 3			Input Type/Range Select Channel 3				Reserved				Input Filter Select Channel 3			

1. The ability to change these values using your control program is not supported by all controllers. Refer to your controller manual for details.

The configuration file is typically modified using the programming software configuration screen.



Note: The software configuration default is to enable each analog input channel. For improved analog input module performance, disable any *unused* channels.

Table: 4.3 Software Configuration Channel Defaults

Parameter	Default Setting
Enable Channel	Enabled
Filter Selection	60 Hz
Input Range	±10V dc
Data Format	Raw/Proportional

The configuration file can also be modified through the control program, if supported by the controller. The structure and bit settings are shown in “Channel Configuration” on page 4-5.

Channel Configuration

Each channel configuration word consists of bit fields, the settings of which determine how the channel operates. See the table below and the descriptions that follow for valid configuration settings and their meanings. The default bit status of the configuration file is all zeros.

Table: 4.4 Bit Definitions for Channel Configuration Words 0 through 3

Bit(s)	Define	These bit settings																Indicate this
		15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0-3	Input Filter Select													0	0	0	0	60 Hz
														0	0	0	1	50 Hz
														0	0	1	0	Not Used
														0	0	1	1	250 Hz
														0	1	0	0	500 Hz
																		Not Used[1]
4-7	Reserved																	Reserved[2]
8-11	Input Type/ Range Select					0	0	0	0									-10 to +10V dc
						0	0	0	1									0 to 5V dc
						0	0	1	0									0 to 10V dc
						0	0	1	1									4 to 20 mA
						0	1	0	0									1 to 5V dc
						0	1	0	1									0 to 20 mA
																		Not Used[1]
12-14	Input Data Format Select		0	0	0													Raw/ Propor-tional Data
			0	0	1													Engineer-ing Units
			0	1	0													Scaled for PID
			0	1	1													Percent Range
																		Not Used[1]
15	Enable Channel	1																Enabled
		0																Disabled

1. Any attempt to write a non-valid (not used) bit configuration into any selection field results in a module configuration error. See "Configuration Errors" on page 6-5.
2. If reserved bits are not equal to zero, a configuration error occurs.

Enable Channel

This configuration selection allows each channel to be individually enabled.

Note: When a channel is not enabled (0), no voltage or current input is provided to the controller by the A/D converter.

Input Filter Selection

The input filter selection field allows you to select the filter frequency for each channel and provides system status of the input filter setting for analog input channels 0 through 3. The filter frequency affects the noise rejection characteristics, as explained below. Select a filter frequency considering acceptable noise and step response time.

Noise Rejection

The 1769-IF4 uses a digital filter that provides noise rejection for the input signals. The filter is programmable, allowing you to select from four filter frequencies for each channel. The digital filter provides the highest noise rejection at the selected filter frequency. A lower frequency (60 Hz versus 250 Hz) can provide better noise rejection but it increases channel update time. Transducer power supply noise, transducer circuit noise, or process variable irregularities may also be sources of normal mode noise.

Common Mode Rejection is better than 60 dB at 50 and 60 Hz, with the 50 and 60 Hz filters selected, respectively. The module performs well in the presence of common mode noise as long as the signals applied to the user plus and minus input terminals do not exceed the common mode voltage rating (± 10 V) of the module. Improper earth ground may be a source of common mode noise.

Channel Step Response

The selected channel filter frequency determines the channel’s step response. The step response is the time required for the analog input signal to reach 100% of its expected final value. This means that if an input signal changes faster than the channel step response, a portion of that signal will be attenuated by the channel filter.

Table: 4.5 Filter Frequency and Step Response

Filter Frequency	Cut-off Frequency	Step Response
50 Hz	13.1 Hz	60 ms
60 Hz	15.7 Hz	50 ms
250 Hz	65.5 Hz	12 ms
500 Hz	131 Hz	6 ms

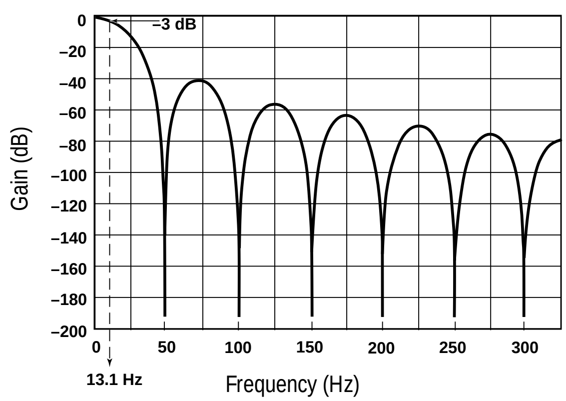
Channel Cut-Off Frequency

The -3 dB frequency is the filter cut-off frequency. The cut-off frequency is defined as the point on the frequency response curve where frequency components of the input signal are passed with 3 dB of attenuation. All input frequency components at or below the cut-off frequency are passed by the digital filter with less than 3 dB of attenuation. All frequency components above the cut-off frequency are increasingly attenuated as shown in the graphs below.

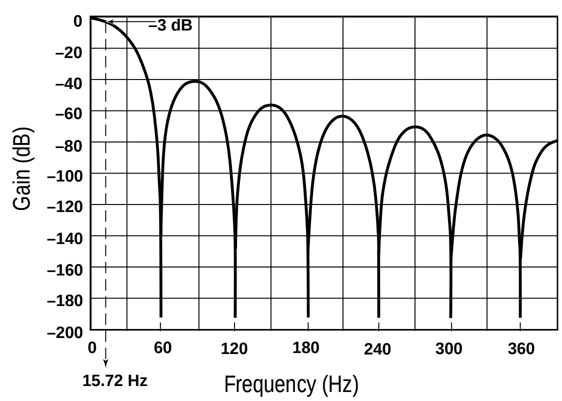
The cut-off frequency for each channel is defined by its filter frequency selection. Choose a filter frequency so that your fastest changing signal is below that of the filter's cut-off frequency. The cut-off frequency should not be confused with the update time. The cut-off frequency relates to how the digital filter attenuates frequency components of the input signal. The update time defines the rate at which an input channel is scanned and its channel data word is updated.

Frequency Response Graphs

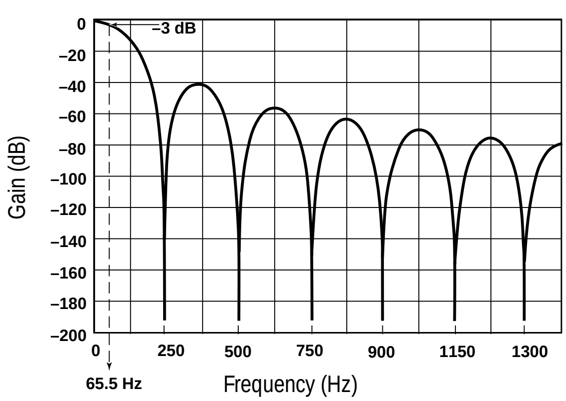
50 Hz Input Filter Frequency



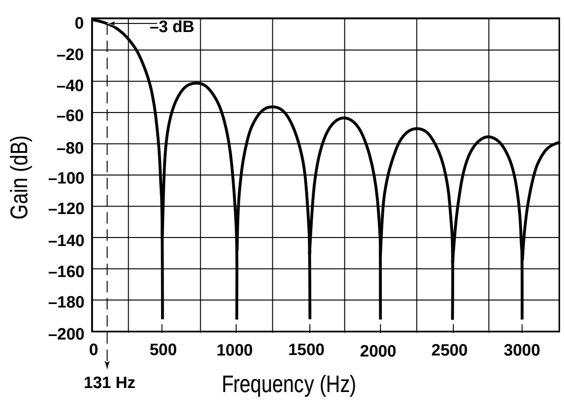
60 Hz Input Filter Frequency



250 Hz Input Filter Frequency

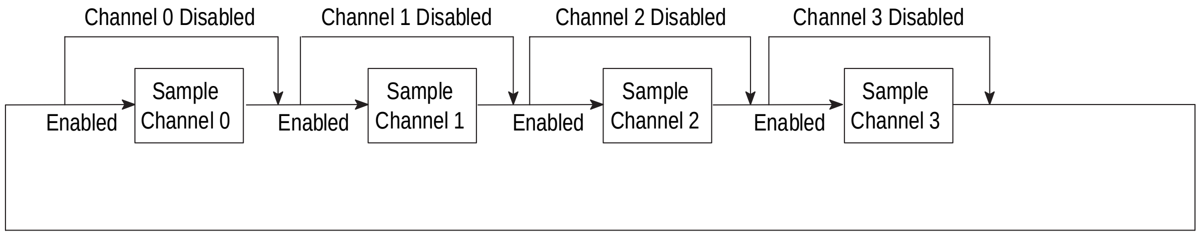


500 Hz Input Filter Frequency



Module Update Time and Scanning Process

The module update time is defined as the time required for the module to sample and convert the input signals of all enabled input channels and provide the resulting data values to the processor. Module update time can be calculated by adding the sum of all enabled channel times. Channel times include channel scan time, channel switching time, and reconfiguration time. The module sequentially samples the channels in a continuous loop as shown below.



The following table shows the channel update times. The fastest module update time occurs when only one channel is enabled with a 500 Hz filter (4 ms). If more than one channel is enabled, the update time is faster if both channels have the same configuration. See “Example 1” on page 4-9. The slowest module update time occurs when all four channels are enabled with different configurations. See “Example 2” on page 4-9.

Table: 4.6 Channel Update Time

Filter Frequency	Channel Update Time
50 Hz	22 ms
60 Hz	19 ms
250 Hz	6 ms
500 Hz	4 ms

Channel Switching and Reconfiguration Times

The table below provides the channel switching and reconfiguration times for a channel.

Table: 4.7 Channel Switching and Reconfiguration Times

	Description	Duration			
		50 Hz	60 Hz	250 Hz	500 Hz
Channel Switching Time	The time it takes the module to switch from one channel to another.	46 ms	39 ms	14 ms	10 ms
Channel-to-Channel Reconfiguration Time	The time it takes the module to change its configuration settings for a difference in configuration between one channel and another.	116 ms	96 ms	20 ms	8 ms

Examples of Calculating Module Update Time

Example 1: Two Channels Enabled with Identical Configurations

The following example calculates the 1769-IF4 module update time for two channels enabled with the same configuration and a 500 Hz filter.

Module Update Time = [Channel 0 Scan Time + Channel 0 Switching Time] + [Channel 1 Scan Time + Channel 1 Switching Time]

28ms = [4 ms + 10 ms] + [4 ms + 10 ms]

Example 2: Three Channels Enabled with Different Configurations

The following example calculates the module update time for three channels with the following configurations:

- Channel 0: ±10V dc with 60 Hz filter
- Channel 1: ±10V dc with 500 Hz filter
- Channel 2: 4 - 20 mA with 250 Hz filter

Module Update Time = [Channel 0 Reconfiguration Time + Channel 0 Scan Time + Channel 0 Switching Time] + [Channel 1 Reconfiguration Time + Channel 1 Scan Time + Channel 1 Switching Time] + [Channel 2 Reconfiguration Time + Channel 2 Scan Time + Channel 2 Switching Time]

= [96 ms + 19 ms + 39 ms] + [8 ms + 4 ms + 10 ms] + [20 ms + 6 ms + 14 m]

216 ms = [154 ms] + [22 ms] + [40 ms]

Input Type/Range Selection

This selection along with proper input wiring allows you to configure each channel individually for current or voltage ranges and provides the ability to read the current range selections.

Input Data Selection Formats

This selection configures channels 0 through 3 to present analog data in any of the following formats:

- Raw/Proportional Data
- Engineering Units
- Scaled for PID
- Percent Range

Raw/Proportional Data

The value presented to the controller is proportional to the selected input and scaled into the maximum data range allowed by the bit resolution of the A/D converter and filter selected. The full range for a ±10Vdc user input is -32767 to +32767. See Table 4.8, “Valid Input Data,” on page 4-11.

Engineering Units

The module scales the analog input data to the actual current or voltage values for the selected input range. The resolution of the engineering units is dependent on the range selected and the filter selected. SeeTable 4.8, “Valid Input Data,” on page 4-11.

Scaled for PID

The value presented to the controller is a signed integer with zero representing the lower user range and 16383 representing the upper user range. Allen-Bradley controllers, such as the MicroLogix 1500, use this range in their PID equations. The amount over and under user range (full scale range -410 to 16793) is also included. See Table 4.8, “Valid Input Data,” on page 4-11.

Percent Range

The input data is presented to the user as a percent of the user range. For example, 0V to 10V dc equals 0% to 100%. See Table 4.8, “Valid Input Data,” on page 4-11.

Note: The ±10V dc range does not support the percent user range data format.

Valid Input Data Word Formats/Ranges

The following table shows the valid formats and min./max. data ranges provided by the module.

Table: 4.8 Valid Input Data

1769-IF4 Input Range	Input Value	Example Data	Input Range Condition	Raw/ Proportional Data	Engineering Unit	Scaled for PID	Percent Full Range
				Decimal Range	Decimal Range	Decimal Range	Decimal Range
-10V to +10V dc	Over 10.5V dc	+11.0V dc	Over-range	32767 (max.)	10500 (max.)	16793 (max.)	N/A
	+10.5V dc	+ 10.5V dc	Over-range	32767 (max.)	10500 (max.)	16793 (max.)	N/A
	-10V to +10V dc	+10.0V dc	Normal	31206	10000	16383	N/A
		0.0V dc	Normal	0	0	8192	N/A
		-10.0V dc	Normal	-31206	-10000	0	N/A
	-10.5Vdc	-10.5V dc	Under-range	-32767 (min.)	-10500 (min.)	-410 (min.)	N/A
	Under -10.5V dc	-11.0V dc	Under-range	-32767 (min.)	-10500 (min.)	-410 (min.)	N/A
0V to 5V dc	Over 5.25V dc	5.5V dc	Over-range	32767 (max.)	5250 (max.)	17202 (max.)	10500 (max.)
	5.25V dc	5.25V dc	Over-range	32767 (max.)	5250 (max.)	17202 (max.)	10500 (max.)
	0.0V dc to 5.0V dc	5.0V dc	Normal	31206	5000	16383	10000
		0.0V dc	Normal	0	0	0	0
	-0.5V dc	-0.5V dc	Under-range	-3121 (min.)	-500 (min.)	-1638 (min.)	-1000 (min.)
	Under -0.5V dc	-1.0V dc	Under-range	-3121 (min.)	-500 (min.)	-1638 (min.)	-1000 (min.)
0V to 10V dc	Over 10.5V dc	11.0V dc	Over-range	32767 (max.)	10500 (max.)	17202 (max.)	10500 (max.)
	+10.5V dc	10.5V dc	Over-range	32767 (max.)	10500 (max.)	17202 (max.)	10500 (max.)
	0.0V dc to 10.0V dc	10.0V dc	Normal	31206	10000	16383	10000
		0.0V dc	Normal	0	0	0	0
	-0.5V dc	-0.5V dc	Under-range	-3120 (min.)	-500 (min.)	-1638 (min.)	-1000 (min.)
	Under -5.0V dc	-1.0V dc	Under-range	-1560 (min.)	-500 (min.)	-819 (min.)	-500 (min.)
4 mA to 20 mA	Over 21.0 mA	22.0 mA	Over-range	32767 (max.)	21000 (max.)	17407 (max.)	10625 (max.)
	21.0 mA	21.0 mA	Over-range	32767 (max.)	21000 (max.)	17407 (max.)	10625 (max.)
	4.0 mA to 20.0 mA	20.0 mA	Normal	31206	20000	16383	10000
		4.0 mA	Normal	6241	4000	0	0
	3.2 mA	3.2 mA	Under-range	4993 (min.)	3200 (min.)	-819 (min.)	-500 (min.)
	Under 3.2 mA	0.0 mA	Under-range	4993 (min.)	3200 (min.)	-819 (min.)	-500 (min.)

Table: 4.8 Valid Input Data

1769-IF4 Input Range	Input Value	Example Data	Input Range Condition	Raw/ Proportional Data	Engineering Unit	Scaled for PID	Percent Full Range
				Decimal Range	Decimal Range	Decimal Range	Decimal Range
1.0V to 5V dc	Over 5.25V dc	5.5V dc	Over-range	32767 (max.)	5250	17407	10625
	+5.25V dc	5.25V dc	Over-range	32767 (max.)	5250	17407	10625
	1.0V to 5.0V dc	5.0V dc	Normal	31206	5000	16383	10000
		1.0V dc	Normal	6243	1000	1	1
	0.5V dc	0.5V dc	Under-range	3121 (min.)	500	-2048	-1250
	Under 0.5V dc	0.0V dc	Under-range	3121 (min.)	500	-2048	-1250
0 mA to 20 mA	Over 21.0 mA	22.0 mA	Over-range	32767	21000	17202	10500
	21.0 mA	21.0 mA	Over-range	32767	21000	17202	10500
	0.0 mA to 20.0 mA	20.0 mA	Normal	31206	20000	16383	10000
		0.0 mA	Normal	0	0	0	0
	Under 0.0 mA	0.0 mA	Under-range	0	0	0	0

Effective Resolution

The effective resolution for an input channel depends upon the filter frequency selected for that channel. The following tables provide the effective resolution for the four frequencies for each of the range selections.

Table: 4.9 50Hz / 60Hz Effective Resolution

1769-IF4 Input Range	Raw/Proportional Data Over the Full Input Range		Engineering Units Over the Full Input Range		Scaled-For-PID Over the Full Input Range		Percent Over the Full Input Range	
	Bits and Engineering Units Resolution	Decimal Range and Count Value	Resolution	Decimal Range and Count Value	Resolution	Decimal Range and Count Value	Resolution	Decimal Range and Count Value
-10 to +10V dc	Sign +14 0.64 mV/ 2 counts	±32767 Count by 2	1.00 mV/ 1 count	±10500 Count by 1	1.22 mV/ 1 count	-410 to +16793 Count by 1	Not Applicable	Not Applicable
0 to +5V dc	Sign +13 0.64 mV/ 4 counts	-3121 to +32767 Count by 4	1.00 mV/ 1 count	-500 to +5250 Count by 1	0.92 mV/ 3 counts	-1638 to +17202 Count by 3	1.00 mV/ 2 counts	-1000 to +10500 Count by 2
0 to +10V dc	Sign +14 0.64 mV/ 2 counts	-1560 to +32767 Count by 2	1.00 mV/ 1 count	-500 to +10500 Count by 1	1.22 mV/ 2 counts	-819 to +17202 Count by 2	1.00 mV/ 1 count	-500 to +10500 Count by 1
+4 to +20 mA	Sign +14 1.28 µA/ 2 counts	+4993 to +32767 Count by 2	2.00 µA/ 2 counts	+3200 to +2100 Count by 2	1.95 µA/ 2 counts	-819 to +17407 Count by 2	1.60 µA/ 1 count	-500 to +10625 Count by 1
+1 to +5V dc	Sign +13 0.64 mV/ 4 counts	+3121 to +32767 Count by 4	1.00 mV/ 1 count	+500 to +5250 Count by 1	0.73 mV/ 3 counts	-2048 to +17407 Count by 3	0.80 mV/ 2 counts	-1250 to +10625 Count by 2
0 to +20 mA	Sign +14 1.28 µA/ 2 counts	0 to +32767 Count by 2	2.00 µA/ 2 counts	0 to +21000 Count by 2	2.44 µA/ 2 counts	0 to +17202 Count by 2	2.00 µA/ 1 count	0 to +10500 Count by 1

Table: 4.10 250Hz Effective Resolution

1769-IF4 Input Range	Raw/Proportional Data Over the Full Input Range		Engineering Units Over the Full Input Range		Scaled-For-PID Over the Full Input Range		Percent Over the Full Input Range	
	Bits and Engineering Units Resolution	Decimal Range and Count Value	Resolution	Decimal Range and Count Value	Resolution	Decimal Range and Count Value	Resolution	Decimal Range and Count Value
-10 to +10V dc	Sign +11 5.13 mV/ 16 counts	±32767 Count by 16	6.00 mV/ 6 counts	±10500 Count by 6	6.10 mV/ 5 counts	-410 to +16793 Count by 5	Not Applicable	Not Applicable
0 to +5V dc	Sign +10 5.13 mV/ 32 counts	-3121 to +32767 Count by 32	6.00 mV/ 6 counts	-500 to +5250 Count by 6	5.19 mV/ 17 counts	-1638 to +17202 Count by 17	5.50 mV/ 11 counts	-1000 to +10500 Count by 11
0 to +10V dc	Sign +11 5.13 mV/ 16 counts	-1560 to +32767 Count by 16	6.00 mV/ 6 counts	-500 to +10500 Count by 6	5.49 mV/ 9 counts	-819 to +17202 Count by 9	6.00 mV/ 6 counts	-500 to +10500 Count by 6
+4 to +20 mA	Sign +11 10.25 µA/ 16 counts	+4993 to +32767 Count by 2	11.00 µA/ 11 counts	+3200 to +2100 Count by 11	10.74 µA/ 11 counts	-819 to +17407 Count by 11	11.20 µA/ 7 counts	-500 to +10625 Count by 7
+1 to +5V dc	Sign +10 5.13 mV/ 32 counts	+3121 to +32767 Count by 32	6.00 mV/ 6 counts	+500 to +5250 Count by 6	5.37 mV/ 22 counts	-2048 to +17407 Count by 22	5.20 mV/ 13 counts	-1250 to +10625 Count by 13
0 to +20 mA	Sign +11 10.25 µA/ 16 counts	0 to +32767 Count by 16	11.00 µA/ 11 counts	0 to +21000 Count by 11	10.99 µA/ 9 counts	0 to +17202 Count by 9	12.00 µA/ 6 counts	0 to +10500 Count by 6

Table: 4.11 500 Hz Effective Resolution

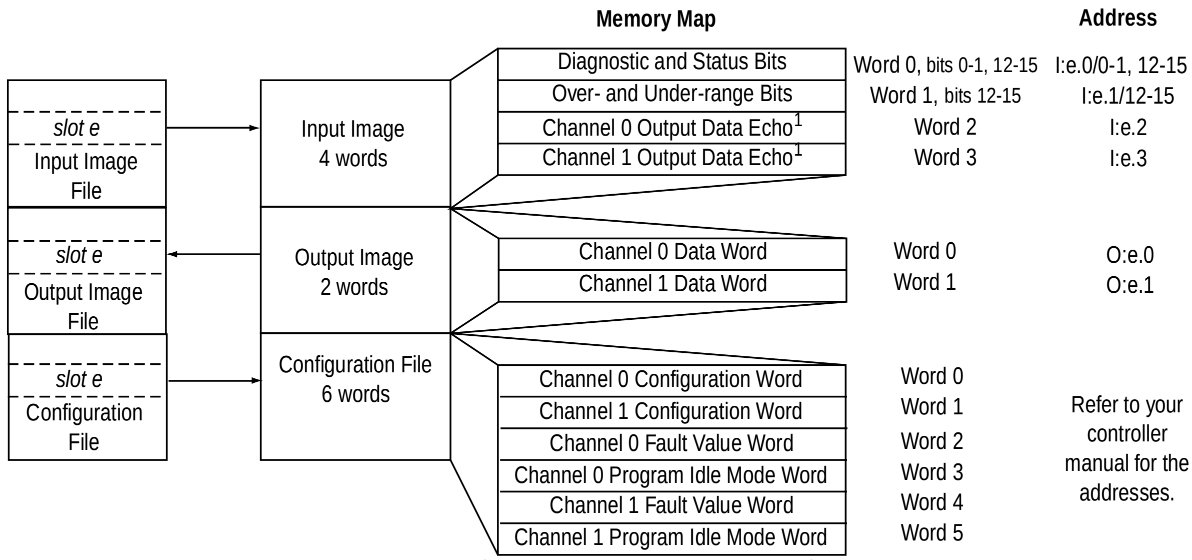
1769-IF4 Input Range	Raw/Proportional Data Over the Full Input Range		Engineering Units Over the Full Input Range		Scaled-For-PID Over the Full Input Range		Percent Over the Full Input Range	
	Bits and Engineering Units Resolution	Decimal Range and Count Value	Resolution	Decimal Range and Count Value	Resolution	Decimal Range and Count Value	Resolution	Decimal Range and Count Value
-10 to +10V dc	Sign +9 20.51 mV/ 64 counts	±32767 Count by 64	21.00 mV/ 21 counts	±10500 Count by 21	20.75 mV/ 17 counts	-410 to +16793 Count by 17	Not Applicable	Not Applicable
0 to +5V dc	Sign +8 20.51 mV/ 128 counts	-3121 to +32767 Count by 128	21.00 mV/ 21 counts	-500 to +5250 Count by 21	20.75 mV/ 68 counts	-1638 to +17202 Count by 68	21.00 mV/ 42 counts	-1000 to +10500 Count by 42
0 to +10V dc	Sign +9 20.51 mV/ 64 counts	-1560 to +32767 Count by 64	21.00 mV/ 21 counts	-500 to +10500 Count by 21	20.75 mV/ 34 counts	-819 to +17202 Count by 34	21.00 mV/ 21 counts	-500 to +10500 Count by 21
+4 to +20 mA	Sign +9 41.02 µA/ 64 counts	+4993 to +32767 Count by 64	42.00 µA/ 42 counts	+3200 to +2100 Count by 42	41.02 µA/ 42 counts	-819 to +17407 Count by 42	41.60 µA/ 26 counts	-500 to +10625 Count by 26
+1 to +5V dc	Sign +8 20.51 mV/ 128 counts	+3121 to +32767 Count by 128	21.00 mV/ 21 counts	+500 to +5250 Count by 21	20.75 mV/ 84 counts	-2048 to +17407 Count by 84	20.8 mV/ 52 counts	-1250 to +10625 Count by 52
0 to +20 mA	Sign +9 41.02 µA/ 64 counts	0 to +32767 Count by 64	42.00 µA/ 42 counts	0 to +21000 Count by 42	41.51 µA/ 34 counts	0 to +17202 Count by 34	42.00 µA/ 21 counts	0 to +10500 Count by 21

Module Data, Status, and Channel Configuration for 1769-OF2

This chapter examines the analog output module’s output data file, input data file, channel status, and channel configuration words.

Output Module Addressing

The following memory map shows the output, input, and configuration tables for the 1769-OF2.



1. See “Output Data Loopback/Echo” on page 5-3.

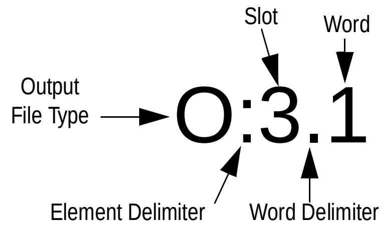
1769-OF2 Output Data File

The structure of the output data file is shown in the table below. Words 0 and 1 contain the converted analog output data for channels 0 and 1, respectively. The most significant bit is the sign bit.

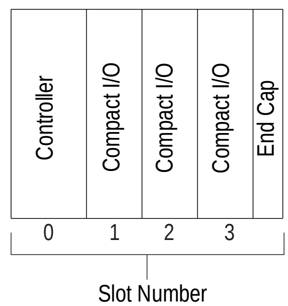
Table: 5.1 1769-OF2 Output Data Table

Word/Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Word 0	SGN	Analog Output Data Channel 0														
Word 1	SGN	Analog Output Data Channel 1														

For example, to obtain the converted output data of channel 1 of an analog module located in slot 3, use address O:3.1.



Note: This addressing scheme is applicable only for the MicroLogix™ 1500 controller.



Note: The end cap does not use a slot address.

1769-OF2 Input Data File

This data table file provides immediate access to channel diagnostic information and analog output data at the module for use in the control program. To receive valid data, you must enable the channel. The data table structure is described below.

Table: 5.2 1769-OF2 Input Data Table

Word/Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Word 0	D0	H0	D1	H1	Not Used (bits set to 0)										S1	S0
Word 1	U0	O0	U1	O1	Bits 0 - 11 set to 0											
Word 2	SGN	Channel 0 - Output Data Loopback/Echo														
Word 3	SGN	Channel 1 - Output Data Loopback/Echo														

Diagnostic Bits (D0 - D1)

When set (1), these bits indicate a broken output wire or high load resistance (not used on voltage outputs). Bit 15 represents channel 0; bit 13 represents channel 1.

Hold Last State Bits (H0 - H1)

These bits indicate when channel 0 (bit 14) or channel 1 (bit 12) is in a hold last state condition. When one of these bits is set (1), the corresponding channel is in the hold state. Output data will not change until the condition which caused the hold last state to occur is removed. The bit is reset (0) for all other conditions.

Note: Not all controllers support the hold last state function. Refer to your controller's user manual for details.

Over-Range Flag Bits (O0 - O1)

Over-range bits for channels 0 and 1 are contained in word 1, bits 14 and 12. When set, the over-range bit indicates that the controller is attempting to drive the analog output above its normal operating range. However, the module continues to convert analog output data to a maximum full range value. The bit is automatically reset (0) by the module when the over-range condition is cleared (the output is within the normal operating range). The over-range bits apply to all output ranges. Refer to Table 5.6, "Valid Output Data Table," on page 5-11 to view the normal operating and over-range areas.

Under-Range Flag Bits (U0 - U1)

Under-range bits for channels 0 and 1 are contained in word 1, bits 15 and 13. When set (1), the under-range bit indicates that the controller is attempting to drive the analog output below its normal operating range. However, the module continues to convert analog output data to a minimum full range value. The bit is automatically reset (0) by the module when the under-range condition is cleared (the output is within the normal operating range). The under-range bits apply to all output ranges. Refer to Table 5.6, "Valid Output Data Table," on page 5-11 to view the normal operating and under-range areas.

General Status Bits (S0 - S1)

Word 0, bits 0 and 1 contain the general status information for output channels 0 and 1. If set (1), these bits indicate an error associated with that channel. The over-range and under-range bits and the diagnostic bit are logically ORed to this position.

Output Data Loopback/Echo

Words 2 and 3 provide output loopback/data echo through the input array for channels 0 and 1, respectively. The value of the data echo is the analog value currently being converted on-board the module by the D/A converter. This ensures that the logic-directed state of the output is true. Otherwise, the state of the output could vary depending on controller mode.

Under normal operating conditions, the data echo value is the same value that is being sent from the controller to the output module. Under abnormal conditions, the values may differ. For example:

1. During run mode, the control program could direct the module to a value over or under the defined full range. In that case, the module raises the over- or under-range flag and continues to convert and data echo up to the defined full range. However, upon reaching either the maximum upper or lower full range value, the module stops converting and echoes back that maximum upper or lower full range value, not the value being sent from the controller.

2. During program or fault mode with Hold Last State or User-Defined Value selected, the module echoes the hold last value or alternate value as selected by the user. For more information on the hold last and user-defined values, see “Fault Value (Channel 0 - 1)” on page 5-10 and “Program/Idle Value (Channel 0 - 1)” on page 5-10.

1769-OF2 Configuration Data File

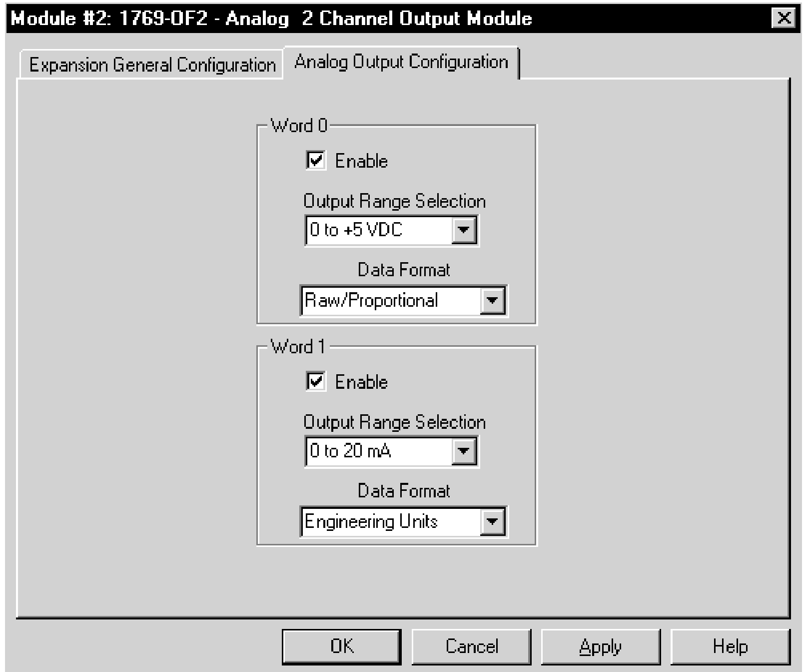
The configuration file allows you to determine how each individual output channel will operate. Parameters such as the output type/range and data format are set up using this file. The configuration data file is writable and readable. The default value for the configuration data file is all zeros. The structure of the channel configuration file is explained below. Words 0 and 1 are the channel configuration words for channels 0 and 1. They are described in “Channel Configuration Words” on page 5-6. Words 2 through 5 are explained beginning on page 5-10.

Table: 5.3 1769-OF2 Configuration Data Table[1]

Word/Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Word 0	E	Output Data Format Select Channel 0			Output Type/Range Select Channel 0				Not Used (set to 0)				FM0	PM0	Not Used (set to 0)	PFE0
Word 1	E	Output Data Format Select Channel 1			Output Type/Range Select Channel 1				Not Used (set to 0)				FM1	PM1	Not Used (set to 0)	PFE1
Word 2	S	Fault Value - Channel 0														
Word 3	S	Program (Idle) Value - Channel 0														
Word 4	S	Fault Value - Channel 1														
Word 5	S	Program (Idle) Value - Channel 1														

1. The ability to change these values using your control program is not supported by all controllers. Refer to your controller manual for details.

The configuration file is typically modified using the programming software configuration screen.



Note: The software configuration default is to enable each output channel. To reduce module power draw and heat dissipation, disable any unused channel.

Table: 5.4 Software Configuration Default Settings

Parameter	Default Setting
Enable Channel	Enabled
Output Range Selection	±10V dc
Data Format	Raw/Proportional

The configuration file can also be modified through the control program, if supported by the controller. The structure and bit settings are shown in “Channel Configuration Words” on page 5-6.

Channel Configuration Words

Both channel configuration words (0 and 1) consist of bit fields, the settings of which determine how the corresponding channel operates. See the table below and the descriptions that follow for valid configuration settings and their meanings.

Table: 5.5 Bit Definitions for Channel Configuration Words 0 and 1

Bit(s)	Define	These bit settings																Indicate this
		15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**	
0	Program/ Idle to Fault Enable																0	Program Mode Data Applied
																	1	Fault Mode Data Applied
1	Reserved																	Reserved
2	Program/ Idle Mode														0			Program Mode Hold Last State
															1			Program Mode User-Defined Value
3	Fault Mode													0				Fault Mode Hold Last State
														1				Fault Mode User-Defined Value
4-7	Reserved																	Reserved[1]
8-11	Output Type/ Range Select					0	0	0	0									-10V dc to +10V dc
						0	0	0	1									0 to 5V dc
						0	0	1	0									0 to 10V dc
						0	0	1	1									4 to 20 mA
						0	1	0	0									1 to 5V dc
						0	1	0	1									0 to 20 mA
																		Not Used[2]
12-14	Output Data Format Select		0	0	0													Raw/ Proportional Data
			0	0	1													Engineering Units
			0	1	0													Scaled for PID
			0	1	1													Percent Range
																		Not Used[2]
15	Enable Channel	1																Enabled
		0																Disabled

1. If reserved bits are not equal to zero, a configuration error occurs.
2. Any attempt to write a non-valid (not used) bit configuration into any selection field results in a module configuration error. See“Configuration Errors” on page 6-5.

Enable Channel

This configuration selection (bit 15) allows each channel to be individually enabled.

Note: A channel that is not enabled has zero voltage or current at its terminal.

Output Type/Range Selection

This selection, along with proper output wiring, allows you to configure each output channel individually for current or voltage ranges, and provides the ability to read the range selection.

Output Data Format Selection

This selection configures each channel to interpret data presented to it by the controller in any of the following formats:

- Raw/Proportional Data
- Engineering Units
- Scaled for PID
- Percent Full Range

Raw/Proportional Data

The control program presents the maximum raw data value allowed by the bit resolution of the D/A converter. The full range for a ± 10Vdc user input is -32767 to +32767. See Table 5.6, “Valid Output Data Table,” on page 5-11.

Engineering Units

The control program presents an engineering data value to the module within the current or voltage range allowed by the D/A converter. The module then scales the data to the appropriate analog output value for the selected user range. See Table 5.6, “Valid Output Data Table,” on page 5-11.

Scaled for PID

The control program presents an integer value to the module, with zero representing the lower user range and 16383 representing the upper user range, for conversion by the D/A converter. The module then scales this data to the approximate analog output value for the selected user range. See Table 5.6, “Valid Output Data Table,” on page 5-11.

Note: Allen-Bradley controllers, such as the MicroLogix 1500, use this range in their PID equations for controlled process outputs.

Percent Full Range

The control program presents the analog output data to the module as a percent of the full analog output range (for example, valve 50% open). The module scales this data to the appropriate analog output value for the selected user range. For example, 0 to 100% equals 0 to 10V dc. See Table 5.6, “Valid Output Data Table,” on page 5-11.

Note: The ±10V dc range does not support percent full range.

Program/Idle to Fault Enable (PFE0 - PFE1)

If a system currently in program/idle mode faults, this setting (word 0, bit 0; word 1, bit 0) determines whether the program/idle or fault mode value is applied to the output. If the selection is enabled [the bit is set (1)], the module applies the fault mode data value. If the selection is disabled [the bit is reset (0)], the module applies the program/idle mode data value. The default setting is disabled.

Note: Not all controllers support this function. Refer to your controller’s user manual for details.

Fault Mode (FM0 - FM1)

This configuration selection provides individual fault mode selection for analog output channels 0 (word 0, bit 3) and 1 (word 1, bit 3). When this selection is disabled [the bit is reset (0)] and the system enters the fault mode, the module *holds* the *last* output *state* value. This means that the analog output remains at the last converted value prior to the condition that caused the system to enter the fault mode.

Important: Hold last state is the default condition for the 1769-OF2 during a control system run-to-fault mode change.

Note: MicroLogix 1500™ does not support the analog output module’s default hold last state function and resets analog outputs to zero when the system enters the fault mode.

If this selection is enabled [the bit is set (1)] and the system enters the fault mode, it commands the module to convert the *user-specified* integer value from the channel’s fault value word (2 or 4) to the appropriate analog output for the range selected. If the default value, 0000, is entered, the output typically converts to the minimum value for the range selected.

For example:

- If the raw/proportional or engineering units data format is selected and zero (0000) is entered in the ±10V dc operating range, the resulting value would be 0V dc.
- If the raw/proportional or engineering units format is selected and zero is entered as the fault value in either a 1 to 5V dc or 4 to 20 mA range, a configuration error results.

See Table 5.6, “Valid Output Data Table,” on page 5-11 for more examples.

Note: Not all controllers support this function. Refer to your controller’s user manual for details.

Program/Idle Mode (PM0 - PM1))

This configuration selection provides individual program/idle mode selection for the analog channels 0 (word 0, bit 2) and 1 (word 1, bit 2). When this selection is disabled [the bit is reset (0)], the module *holds* the *last state*, meaning that the analog output remains at the last converted value prior to the condition that caused the control system to enter the program mode.

Important: Hold last state is the default condition for the 1769-OF2 during a control system run-to-program mode change.

Note: MicroLogix 1500™ does not support the analog output module’s default hold last state function and resets analog outputs to zero when the system enters the program mode.

If this selection is enabled [the bit is set (1)] and the system enters the program mode, it commands the module to convert the *user-specified* value from the channel’s program/idle value word (3 or 5) to the appropriate analog output for the range selected.

For example:

- If the default value, 0000, is used and the range selected is 0 - 20 mA, the module will output 0 mA for all data formats.
- If the raw/proportional or engineering units format is selected and zero is entered as the program/idle value in either a 1 to 5V dc or 4 to 20 mA range, a configuration error results. See Table 5.6, “Valid Output Data Table,” on page 5-11 for more examples.

Note: Not all controllers support this function. Refer to your controller’s user manual for details.

Fault Value (Channel 0 - 1)

Using words 2 and 4 for channels 0 and 1, you can specify the values the outputs will assume when the system enters the fault mode. The default value is 0. Valid values are dependent upon the range selected in the range selection field. If the value entered by the user is outside the normal operating range for the output range selected, the module generates a configuration error.

For example, if you select engineering units for the ±10V dc range and enter a fault value within the normal operating range (0 to 10000), the module will configure and operate correctly. However, if you enter a value outside the normal operating range (for example 11000), the module indicates a configuration error.

Note: Not all controllers support this function. Refer to your controller's user manual for details.

Program/Idle Value (Channel 0 - 1)

Use words 3 and 5 to set the integer values for the outputs to assume when the system enters the program mode. The values are dependent upon the range selected in the range selection field. If the value entered by the user is outside the normal operating range for the output range selected, the module generates a configuration error. The default value is 0.

Note: Not all controllers support this function. Refer to your controller's user manual for details.

Valid Output Data Word Formats/Ranges

The following table shows the valid formats and data ranges accepted by the module.

Table: 5.6 Valid Output Data Table

OF2 Output Range	Input Value	Example Data		Output Range State	Raw/ Proportional Data		Engineering Unit		Scaled for PID		Percent Full Range	
					Decimal Range		Decimal Range		Decimal Range		Decimal Range	
		Controller Ordered	OF2 Output		Controller Ordered	OF2 Output and Echo	Controller Ordered	OF2 Output and Echo	Controller Ordered	OF2 Output and Echo	Controller Ordered	OF2 Output and Echo
±10V dc	Over 10.5V dc	+11.0V dc	+10.5V dc	Over	N/A	N/A	11000	10500	17202	16793	N/A	N/A
	+10.5V dc	+10.5V dc	+10.5V dc	Over	32767	32767	10500	10500	16793	16793	N/A	N/A
	-10V to +10V dc	+10.0V dc	+10.0V dc	Normal	31207	31207	10000	10000	16383	16383	N/A	N/A
		0.0V dc	0.0V dc	Normal	0	0	0	0	8192	8192	N/A	N/A
		-10.0V dc	-10.0V dc	Normal	-31207	-31207	-10000	-10000	0	0	N/A	N/A
	-10.5V dc	-10.5V dc	-10.5V dc	Under	-32767	-32767	-10500	-10500	-410	-410	N/A	N/A
	Under -10.5V dc	-11.0V dc	-11.0V dc	Under	N/A	N/A	-11000	-10500	-819	-410	N/A	N/A
0V to 5V dc	Over 5.25V dc	5.5V dc	+5.25V dc	Over	N/A	N/A	5500	5250	18021	17202	11000	10500
	5.25V dc	5.25V dc	+5.25V dc	Over	32767	32767	5250	5250	17202	17202	10500	10500
	0.0V dc to 5.0V dc	5.0V dc	+5.0V dc	Normal	31207	31207	5000	5000	16383	16383	10000	10000
		0.0V dc	0.0V dc	Normal	0	0	0	0	0	0	0	0
	-0.5V dc	-0.5V dc	-0.5V dc	Under	-3121	-3121	-500	-500	-1638	-1638	-1000	-1000
	Under -0.5V dc	-1.0V dc	-0.5V dc	Under	-6241	-3121	-500	-500	-3277	-1638	-2000	-1000
0V to 10V dc	Over 10.5V dc	11.0V dc	+10.5V dc	Over	N/A	N/A	11000	10500	18021	17202	11000	10500
	+10.5V dc	+10.5V dc	+10.5V dc	Over	32767	32767	10500	10500	17202	17202	10500	10500
	0.0V dc to 10.0V dc	+10.0V dc	+10.0V dc	Normal	31207	31207	10000	10000	16383	16383	10000	10000
		0.0V dc	0.0V dc	Normal	0	0	0	0	0	0	0	0
	-0.5V dc	-0.5V dc	-0.5V dc	Under	-1560	-1560	-500	-500	-819	-819	-500	-500
	Under -5.0V dc	-1.0V dc	-0.5V dc	Under	-3121	-1560	-1000	-500	-1638	-819	-1000	-500
4 mA to 20 mA	Over 21.0 mA	+22.0 mA	+21.0 mA	Over	N/A	N/A	22000	21000	18431	17407	11250	10625
	21.0 mA	+21.0 mA	+21.0 mA	Over	32767	32767	21000	21000	17407	17407	10625	10625
	4.0 mA to 20.0 mA	+20.0 mA	+20.0 mA	Normal	31207	31207	20000	20000	16383	16383	10000	10000
		+4.0 mA	+4.0 mA	Normal	6241	6241	4000	4000	0	0	0	0
	3.2 mA	+3.2 mA	+3.2 mA	Under	4993	4993	3200	3200	-819	-819	-500	-500
	Under 3.2 mA	0.0 mA	+3.2 mA	Under	0	4993	0	3200	-4096	-819	-2500	-500

Table: 5.6 Valid Output Data Table

OF2 Output Range	Input Value	Example Data		Output Range State	Raw/ Proportional Data		Engineering Unit		Scaled for PID		Percent Full Range	
					Decimal Range		Decimal Range		Decimal Range		Decimal Range	
		Controller Ordered	OF2 Output		Controller Ordered	OF2 Output and Echo	Controller Ordered	OF2 Output and Echo	Controller Ordered	OF2 Output and Echo	Controller Ordered	OF2 Output and Echo
1.0V to 5V dc	Over 5.25V dc	+5.5V dc	+5.25V dc	Over	N/A	N/A	5500	5250	18431	17407	11250	10625
	+5.25V dc	+5.25V dc	+5.25V dc	Over	32767	32767	5250	5250	17407	17407	10625	10625
	1.0V to 5.0V dc	+5.0V dc	+5.0V dc	Normal	31207	31207	5000	5000	16383	16383	10000	10000
		+1.0V dc	+1.0V dc	Normal	6241	6241	1000	1000	0	0	0	0
	0.5V dc	+0.5V dc	+0.5V dc	Under	3121	3121	500	500	-2048	-2048	-1250	-1250
	Under 0.5V dc	0.0V dc	0.0V dc	Under	0	3121	0	500	-4096	-2048	-2500	-1250
0 mA to 20 mA	Over 21.0 mA	+22.0 mA	+21.0 mA	Over	N/A	N/A	22000	21000	18201	17202	11000	10500
	21.0 mA	21.0 mA	+21.0 mA	Over	32767	32767	21000	21000	17202	17202	10500	10500
	0.0 mA to 20.0 mA	20.0 mA	+20.0 mA	Normal	31207	31207	20000	20000	16383	16383	10000	10000
		0.0 mA	0.0 mA	Normal	0	0	0	0	0	0	0	0
	Under 0.0 mA	-1.0 mA	0.0 mA	Under	-1560	0	0	-1000	-819	0	-500	0

Module Resolution

The resolution of an analog output channel depends on the output type/range and data format selected. Table 5.7 provides detailed resolution information for the 1769-OF2.

Table: 5.7 Output Resolution

1769-OF2 Output Range	Raw/Proportional Data Over the Full Input Range		Engineering Units Over the Full Input Range		Scaled-For-PID Over the Full Input Range		Percent Over the Full Input Range	
	Bits and Engineering Units Resolution	Decimal Range and Count Value	Resolution	Decimal Range and Count Value	Resolution	Decimal Range and Count Value	Resolution	Decimal Range and Count Value
-10 to +10V dc	Sign +14 0.64 mV/ 2 counts	±32767 Count by 2	2.00 mV/ 2 counts	±10500 Count by 2	2.44 mV/ 2 counts	-410 to +16793 Count by 2	Not Applicable	Not Applicable
0 to +5V dc	Sign +13 0.64 mV/ 4 counts	-3121 to +32767 Count by 4	2.00 mV/ 2 counts	-500 to +5250 Count by 2	0.92 mV/ 3 counts	-1638 to +17202 Count by 3	1.00 mV/ 2 counts	-1000 to +10500 Count by 2
0 to +10V dc	Sign +14 0.64 mV/ 2 counts	-1560 to +32767 Count by 2	2.00 mV/ 2 counts	-500 to +10500 Count by 2	1.22 mV/ 2 counts	-819 to +17202 Count by 2	2.00 mV/ 2 counts	-500 to +10500 Count by 2
+4 to +20 mA	Sign +14 1.28 µA/ 2 counts	+4993 to +32767 Count by 2	2.00 µA/ 2 counts	+3200 to +2100 Count by 2	1.95 µA/ 2 counts	-819 to +17407 Count by 2	3.20 µA/ 2 counts	-500 to +10625 Count by 2
+1 to +5V dc	Sign +13 0.64 mV/ 4 counts	+3121 to +32767 Count by 4	2.00 mV/ 2 counts	+500 to +5250 Count by 2	0.73 mV/ 3counts	-2048 to +17407 Count by 3	0.80 mV/ 2 counts	-1250 to +10625 Count by 2
0 to +20 mA	Sign +14 1.28 µA/ 2 counts	0 to +32767 Count by 2	2.00 µA/ 2 counts	0 to +21000 Count by 2	2.44 µA/ 2 counts	0 to +17202 Count by 2	4.00 µA/ 2 counts	0 to +10500 Count by 2

Module Diagnostics and Troubleshooting

This chapter describes troubleshooting the analog input and output modules. This chapter contains information on:

- safety considerations when troubleshooting
- module vs. channel operation
- the module's diagnostic features
- critical vs. non-critical errors
- module condition data

Safety Considerations

Safety considerations are an important element of proper troubleshooting procedures. Actively thinking about the safety of yourself and others, as well as the condition of your equipment, is of primary importance.

The following sections describe several safety concerns you should be aware of when troubleshooting your control system.

ATTENTION: Never reach into a machine to actuate a switch because unexpected motion can occur and cause injury.

ATTENTION: Remove all electrical power at the main power disconnect switches before checking electrical connections or inputs/outputs causing machine motion.

Indicator Lights

When the green LED on the analog module is illuminated, it indicates that power is applied to the module.

Activating Devices When Troubleshooting

When troubleshooting, never reach into the machine to actuate a device. Unexpected machine motion could occur.

Stand Clear of the Machine

When troubleshooting any system problem, have all personnel remain clear of the machine. The problem could be intermittent, and sudden unexpected machine motion could occur. Have someone ready to operate an emergency stop switch in case it becomes necessary to shut off power to the machine.

Program Alteration

There are several possible causes of alteration to the user program, including extreme environmental conditions, Electromagnetic Interference (EMI), improper grounding, improper wiring connections, and unauthorized tampering. If you suspect a program has been altered, check it against a previously saved program on an EEPROM or UVPROM memory module.

Safety Circuits

Circuits installed on the machine for safety reasons, like over travel limit switches, stop push buttons, and interlocks, should always be hard-wired to the master control relay. These devices must be wired in series so that when any one device opens, the master control relay is de-energized, thereby removing power to the machine. Never alter these circuits to defeat their function. Serious injury or machine damage could result.

Module Operation vs. Channel Operation

The module performs operations at two levels:

- module level
- channel level

Module-level operations include functions such as power-up, configuration, and communication with a bus master, such as a MicroLogix 1500 controller.

Channel-level operations describe channel related functions, such as data conversion and over- or under-range detection.

Internal diagnostics are performed at both levels of operation. When detected, module error conditions are immediately indicated by the module status LED. Both module hardware and channel configuration error conditions are reported to the controller. Channel over-range or under-range conditions are reported in the module's input data table. Module hardware errors are typically reported in the controller's I/O status file. Refer to your controller manual for details.

When a fault condition is detected, the analog outputs are reset to zero. The data in the output data file is retained during the fault. Once the fault condition is corrected and the major fault bit in the controller is cleared, the retained data is sent to the analog output channels.

Power-up Diagnostics

At module power-up, a series of internal diagnostic tests are performed. These diagnostic tests must be successfully completed or the module status LED remains off and a module error results and is reported to the controller.

Table: 6.1 Module Status LED State Table

If module status LED is:	Indicated condition:	Corrective action:
On	Proper Operation	No action required.
Off	Module Fault	Cycle power. If condition persists, replace the module. Call your local distributor or Allen-Bradley for assistance.

Channel Diagnostics

When an input or output module channel is enabled, the module performs a diagnostic check to see that the channel has been properly configured. In addition, the channel is tested on every scan for configuration errors, over-range and under-range, open-circuit (input module in 4 to 20 mA range only) and output wire broken/high load resistance (output module only) conditions.

Out-of-Range Detection (Input and Output Modules)

For input modules, whenever the data received at the channel word is out of the defined operating range, an over-range or under-range error is indicated in input data word 5, bits 8 to 15.

For output modules, whenever the controller is driving data over or under the defined operating range, an over-range or under-range error is indicated in the input data word 1, bits 12 to 15.

Open-Circuit Detection (Input Module Only)

An open-circuit test is performed on all enabled channels configured for 4 to 20 mA inputs. Whenever an open-circuit condition occurs, the under-range bit for that channel is set in input data word 5.

Possible causes of an open circuit include:

- the sensing device may be broken
- a wire may be loose or cut
- the sensing device may not be installed on the configured channel

Output Wire Broken/High Load Resistance (Output Module Only)

A check is performed on all enabled channels to determine if an output wire is broken, or if the load resistance is high, in the case of current mode outputs. Whenever one of these conditions is present, the diagnostic bit for that channel is set in the input data word 0, bits 13 or 15.

Non-critical vs. Critical Module Errors

Non-critical module errors are typically recoverable. Channel errors (over-range or under-range errors) are non-critical. Non-critical error conditions are indicated in the module input data table. Non-critical configuration errors are indicated by the extended error code. See Table 6.4, “Extended Error Codes,” on page 6-6.

Critical module errors are conditions that prevent normal or recoverable operation of the system. When these types of errors occur, the system typically leaves the run or program mode of operation until the error can be dealt with. Critical module errors are indicated in Table 6.4, “Extended Error Codes,” on page 6-6.

Module Error Definition Table

Analog module errors are expressed in two fields as four-digit Hex format with the most significant digit as “don’t care” and irrelevant. The two fields are “Module Error” and “Extended Error Information”. The structure of the module error data is shown below.

Table: 6.2 Module Error Table

“Don’t Care” Bits				Module Error			Extended Error Information								
15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hex Digit 4				**Hex Digit 3**				**Hex Digit 2**				**Hex Digit 1**			

Module Error Field

The purpose of the module error field is to classify module errors into three distinct groups, as described in the table below. The type of error determines what kind of information exists in the extended error information field. These types of module errors are typically reported in the controller’s I/O status file. Refer to your controller manual for details.

Table: 6.3 Module Error Types

Error Type	Module Error Field Value (Hex)	Description
No Errors	0	No error is present. The extended error field holds no additional information.
Hardware Errors	2	General and specific hardware error codes are specified in the extended error information field.
Configuration Errors	4	Module-specific error codes are indicated in the extended error field. These error codes correspond to options that you can change directly. For example, the input range or input filter selection.

Extended Error Information Field

Check the extended error information field when a non-zero value is present in the module error field. Depending upon the value in the module error field, the extended error information field can contain error codes that are module-specific or common to all 1769 analog modules.

Note: If no errors are present in the module error field, the extended error information field will be set to zero.

Hardware Errors

General or module-specific hardware errors are indicated by module error code 2. See Table 6.4, "Extended Error Codes," on page 6-6.

Configuration Errors

If you set the fields in the configuration file to invalid or unsupported values, the module ignores the invalid configuration, generates a non-critical error, and keeps operating with the previous configuration.

Each type of analog module has different features and different error codes. Table 6.4, "Extended Error Codes," on page 6-6 lists the possible module-specific configuration error codes defined for the modules.

Error Codes

The table below explains the extended error code.

Table: 6.4 Extended Error Codes

Error Type	Hex Equivalent[1]	Module Error Code	Extended Error Information Code	Error Description
		Binary	Binary	
No Error	X000	000	0 0000 0000	No Error
General Common Hardware Error	X200	001	0 0000 0000	General hardware error; no additional information
	X201	001	0 0000 0001	Power-up reset state
Hardware-Specific Error	X210	001	0 0001 0000	General hardware error
	X211	001	0 0001 0001	Microprocessor hardware error
1769-IF4 Specific Configuration Error	X400	010	0 0000 0000	General configuration error; no additional information
	X401	010	0 0000 0001	invalid input range selected (channel 0)
	X402	010	0 0000 0010	invalid input range selected (channel 1)
	X403	010	0 0000 0011	invalid input range selected (channel 2)
	X404	010	0 0000 0100	invalid input range selected (channel 3)
	X405	010	0 0000 0101	invalid input filter selected (channel 0)
	X406	010	0 0000 0110	invalid input filter selected (channel 1)
	X407	010	0 0000 0111	invalid input filter selected (channel 2)
	X408	010	0 0000 1000	invalid input filter selected (channel 3)
	X409	010	0 0000 1001	invalid input format selected (channel 0)
	X40A	010	0 0000 1010	invalid input format selected (channel 1)
	X40B	010	0 0000 1011	invalid input format selected (channel 2)
	X40C	010	0 0000 1100	invalid input format selected (channel 3)
1769-OF2 Specific Configuration Error	X400	010	0 0000 0000	General configuration error; no additional information
	X401	010	0 0000 0001	invalid output range selected (channel 0)
	X402	010	0 0000 0010	invalid output range selected (channel 1)
	X403	010	0 0000 0010	invalid output data format selected (channel 0)
	X404	010	0 0000 0100	invalid output data format selected (channel 1)
	X405	010	0 0000 0101	invalid fault value entered for data format selected (channel 0)
	X406	010	0 0000 0110	invalid fault value entered for data format selected (channel 1)
	X407	010	0 0000 0111	invalid program value entered for data format selected (channel 0)
	X408	010	0 0000 1000	invalid program value entered for data format selected (channel 1)

1. X represents the “Don’t Care” digit.

Contacting Allen-Bradley

If you need to contact Allen-Bradley for assistance, please have the following information available when you call:

- a clear statement of the problem, including a description of what the system is actually doing. Note the LED state; also note input and output image words for the module.
- a list of remedies you have already tried
- processor type and firmware number (See the label on the processor.)
- hardware types in the system, including all I/O modules
- fault code if the processor is faulted

Specifications

General Specifications for 1769-IF4 and 1769-OF2

Specification	Value
Dimensions	118 mm (height) x 87 mm (depth) x 35 mm (width) height including mounting tabs is 138 mm 4.65 in. (height) x 3.43 in (depth) x 1.38 in (width) height including mounting tabs is 5.43 in.
Approximate Shipping Weight (with carton)	300g (0.65 lbs.)
Storage Temperature	-40°C to +85°C (-40°F to +185°F)
Operating Temperature	0°C to +60°C (32°F to +140°F)
Operating Humidity	5% to 95% non-condensing
Operating Altitude	2000 meters (6561 feet)
Vibration	Operating: 10 to 500 Hz, 5G, 0.015 in. peak-to-peak Relay Operation: 2G
Shock	Operating: 30G, 11ms panel mounted (20G, 11ms DIN rail mounted) Relay Operation: 7.5G panel mounted (5G DIN rail mounted) Non-Operating: 40G panel mounted (30G DIN rail mounted)
Power Supply Distance Rating	8 (The module may not be more than 8 modules away from a system power supply.)
Recommended Cable	Belden™ 8761 (shielded)
Maximum Cable Length	1769-IF4: See “Effect of Transducer/Sensor and Cable Length Impedance on Voltage Input Accuracy” on page 3-10. 1769-OF2: See “Effect of Device and Cable Output Impedance on Output Module Accuracy” on page 3-11.
Agency Certification	• C-UL certified (under CSA C22.2 No. 142) • UL 508 listed • CE compliant for all applicable directives
Hazardous Environment Class	Class I, Division 2, Hazardous Location, Groups A, B, C, D (UL 1604, C-UL under CSA C22.2 No. 213)
Radiated and Conducted Emissions	EN50081-2 Class A
Electrical /EMC:	*The module has passed testing at the following levels:*
• ESD Immunity (IEC1000-4-2)	• 4k V contact, 8kV air, 4k V indirect
• Radiated Immunity (IEC1000-4-3)	• 10 V/m , 80 to 1000 MHz, 80% amplitude modulation, +900 MHz keyed carrier
• Fast Transient Burst (IEC1000-4-4)	• 2 kV, 5kHz
• Surge Immunity (IEC1000-4-5)	• 2 kV common mode, 1kV differential mode
• Conducted Immunity (IEC1000-4-6)	• 10V, 0.15 to 80MHz[1]

1. Conducted Immunity frequency range may be 150 kHz to 30 MHz if the Radiated Immunity frequency range is 30 MHz to 1000 MHz.

1769-IF4 Input Specifications

Specification	1769-IF4
Analog Normal Operating Ranges	Voltage: ± 10V dc, 0 to 10V dc, 0 to 5V dc, 1 to 5V dc Current: 0 to 20 mA, 4 to 20 mA
Full Scale[1] Analog Ranges	Voltage: ± 10.5V dc, -0.5 to 10.5V dc, -0.5 to 5.25V dc, 0.5 to 5.25V dc Current: 0 to 21 mA, 3.2 to 21 mA
Number of Inputs	4 differential or single-ended
Bus Current Draw (max.)	120 mA at 5V dc 150 mA at 24V dc
Heat Dissipation	3.99 Total Watts (The Watts per point, plus the minimum Watts, with all points energized.)
Converter Type	Delta Sigma
Response Speed per Channel	Input filter and configuration dependent. See “Channel Step Response” on page 4-6.
Resolution (max.)	14 bits (unipolar) 14 bits plus sign (bipolar) See “Effective Resolution” on page 4-12.
Rated Working Voltage[2]	50V ac/50V dc
Common Mode Voltage Range[3]	±10V maximum per channel
Common Mode Rejection	greater than 60 dB at 50 and 60 Hz with the 50 or 60 Hz filter selected, respectively
Normal Mode Rejection Ratio	-50 dB at 50/60 Hz
Input Impedance	Voltage Terminal: 220K Ω (typical) Current Terminal: 250 Ω
Overall Accuracy[4]	Voltage Terminal: ±0.2% full scale at 25°C Current Terminal: ±0.35% full scale at 25°C
Accuracy Drift with Temperature	Voltage Terminal: ±0.003% per °C Current Terminal: ±0.0045% per °C
Calibration	The module performs autocalibration on channel enable and on configuration change between channels.

1. The over- or under-range flag will come on when the normal operating range (over/under) is exceeded. The module will continue to convert the analog input up to the maximum full scale range.
2. Rated working voltage is the maximum continuous voltage that can be applied at the input terminal, including the input signal and the value that floats above ground potential (for example, 30V dc input signal and 20V dc potential above ground).
3. For proper operation, both the plus and minus input terminals must be within ±10V dc of analog common.
4. Includes offset, gain, non-linearity and repeatability error terms.

1769-IF4 Input Specifications (continued)

Specification	1769-IF4
Non-linearity (in percent full scale)	±0.03%
Repeatability[1]	±0.03%
Module Error over Full Temperature Range (0 to +60°C [+32°F to +140°F])	Voltage: ±0.3% Current: ±0.5%
Input Channel Configuration	via configuration software screen or the user program (by writing a unique bit pattern into the module's configuration file). Refer to your controller manual to determine if user program configuration is supported.
Module OK LED	On: module has power, has passed internal diagnostics, and is communicating over the bus. Off: Any of the above is not true.
Channel Diagnostics	Over or under range by bit reporting
Maximum Overload at Input Terminals	Voltage Terminal: ±30V continuous, 0.1 mA Current Terminal: ±32 mA continuous, ±7.6 V
Input Group to Backplane Isolation	Verified by one of the following dielectric tests: 1200V ac for 1 s or 1697V dc for 1 s. 50V ac/50V dc working voltage (IEC Class 2 reinforced insulation)
Vendor I.D. Code	1
Product Type Code	10
Product Code	35

1. Repeatability is the ability of the input module to register the same reading in successive measurements for the same input signal.

1769-OF2 Output Specifications

Specification	1769-OF2
Analog Ranges	Voltage: ± 10V dc, 0 to 10V dc, 0 to 5V dc, 1 to 5V dc Current: 0 to 20 mA, 4 to 20 mA
Full Scale Analog Ranges	Voltage: ± 10.5V dc, -0.5 to 10.5V dc, -0.5 to 5.25V dc, 0.5 to 5.25V dc Current: 0 - 21 mA, 3.2 - 21 mA
Number of Outputs	2 single-ended
Bus Current Draw (max.)	120 mA at 5V dc 200 mA at 24V dc
Heat Dissipation	4.77 Total Watts *(The Watts per point, plus the minimum Watts, with all points energized.)*
Converter Type	R-2R Ladder
Analog Data Format	14-bit, two's complement. The Most Significant Bit is the sign bit.
Digital Resolution Across Full Range	14 bits (unipolar) 14 bits plus sign (bipolar) See "Module Resolution" on page 5-13.
Conversion Rate (all channels) max.	2.5 ms
Step Response to 63%[1]	2.9 ms
Current Load on Voltage Output	5 mA max.
Resistive Load on Current Output	0 to 500 Ω (includes wire resistance)
Load Range on Voltage Output	>1 kΩ at 5V dc >2 kΩ at 10V dc
Max. Inductive Load (Current Outputs)	0.1 mH
Max. Capacitive Load (Voltage Outputs)	1 µF
Overall Accuracy[2]	Voltage Terminal: ±0.5% full scale at 25°C Current Terminal: ±0.35% full scale at 25°C
Accuracy Drift with Temperature	Voltage Terminal: ±0.0086% FS per °C Current Terminal: ±0.0058% FS per °C
Output Ripple; range 0 - 50 kHz (referred to output range)	±0.05%
Calibration	None required (guaranteed by hardware design).

1. Step response is the period of time between when the D/A converter was instructed to go from minimum to full range until the device is at 63% of full range. Time applies to one or both channels.

2. Includes offset, gain, non-linearity and repeatability error terms.

1769-OF2 Output Specifications (continued)

Specification	1769-OF2
Non-linearity (in percent full scale)	±0.05%
Repeatability[1] (in percent full scale)	±0.05%
Output Error Over Full Temperature Range (0 to 60°C [32 to +140°F])	Voltage: ±0.8% Current: ±0.55%
Output Impedance	15 Ω (typical)
Open and Short-Circuit Protection	Yes
Maximum Short-Circuit Current	21 mA
Output Overvoltage Protection	Yes
Time to Detect Open Wire Condition (Current Mode)	10 ms typical 13.5 ms maximum
Output Response at Power Up and Power Down	±0.5 V spike for <5 ms
Rated Working Voltage[2]	50V ac/50V dc
Module OK LED	On: module has power, has passed internal diagnostics, and is communicating over the bus. Off: Any of the above is not true.
Channel Diagnostics	Over or under range by bit reporting output wire broken or load resistance high by bit reporting (current mode only)
Output Group to Backplane Isolation	Verified by one of the following dielectric tests: 1200V ac for 1 s or 1697V dc for 1 s. 50V ac/50V dc working voltage (IEC Class 2 reinforced insulation)
Vendor I.D. Code	1
Product Type Code	10
Product Code	32

1. Repeatability is the ability of the output module to reproduce output readings when the same controller value is applied to it consecutively, under the same conditions and in the same direction.

2. Rated working voltage is the maximum continuous voltage that can be applied at the input terminal, including the input signal and the value that floats above ground potential (for example, 30V dc input signal and 20V dc potential above ground).

Two’s Complement Binary Numbers

The processor memory stores 16-bit binary numbers. Two’s complement binary is used when performing mathematical calculations internal to the processor. Analog input values from the analog modules are returned to the processor in 16-bit two’s complement binary format. For positive numbers, the binary notation and two’s complement binary notation are identical.

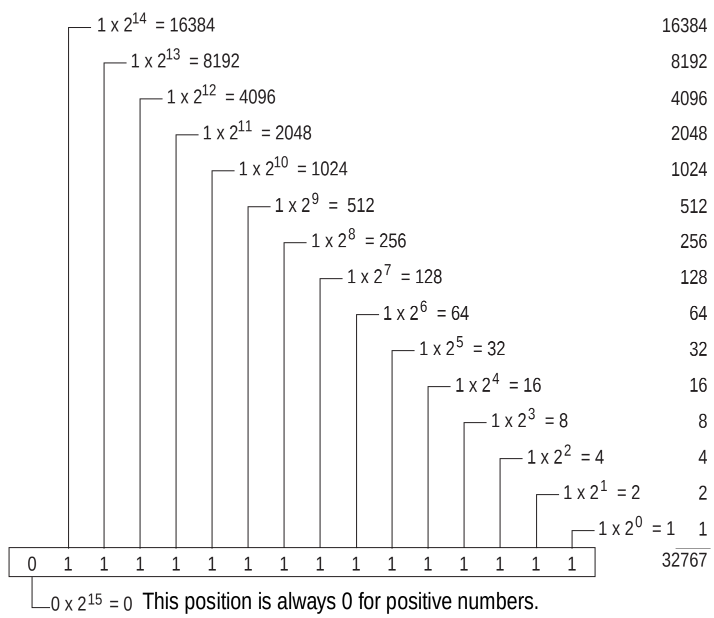
As indicated in the figure on the next page, each position in the number has a decimal value, beginning at the right with 2^0 and ending at the left with 2^{15}. Each position can be 0 or 1 in the processor memory. A 0 indicates a value of 0; a 1 indicates the decimal value of the position. The equivalent decimal value of the binary number is the sum of the position values.

Positive Decimal Values

The far left position is always 0 for positive values. As indicated in the figure below, this limits the maximum positive decimal value to 32767 (all positions are 1 except the far left position). For example:

0000 1001 0000 1110 = $2^{11}+2^8+2^3+2^2+2^1$ = 2048+256+8+4+2 = 2318

0010 0011 0010 1000 = $2^{13}+2^9+2^8+2^5+2^3$ = 8192+512+256+32+8 = 9000

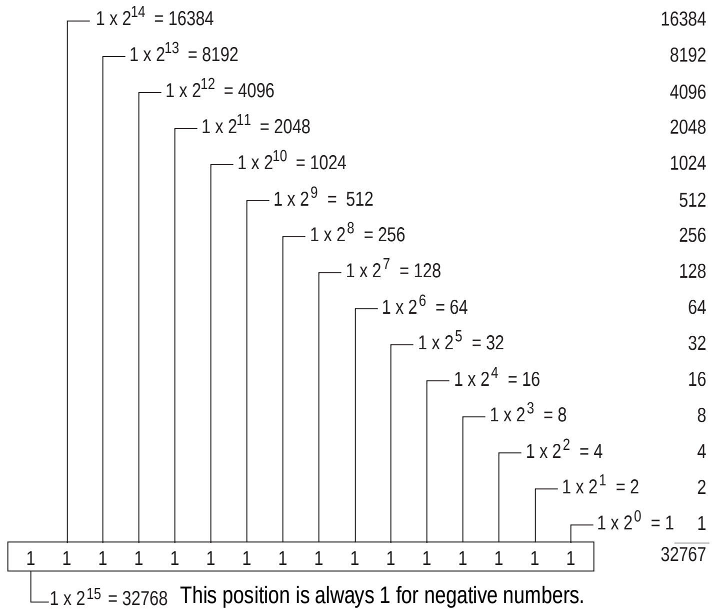


Negative Decimal Values

In two's complement notation, the far left position is always 1 for negative values. The equivalent decimal value of the binary number is obtained by subtracting the value of the far left position, 32768, from the sum of the values of the other positions. In the figure below (all positions are 1), the value is 32767 - 32768 = -1. For example:

1111 1000 0010 0011 = $(2^{14}+2^{13}+2^{12}+2^{11}+2^{5}+2^{1}+2^{0}) - 2^{15}$ =

(16384+8192+4096+2048+32+2+1) - 32768 = 30755 - 32768 = -2013



Glossary

The following terms and abbreviations are used throughout this manual. For definitions of terms not listed here refer to *Allen-Bradley's Industrial Automation Glossary,* Publication AG-7.1.

A/D Converter– Refers to the analog to digital converter inherent to the module. The converter produces a digital value whose magnitude is proportional to the magnitude of an analog input signal.

alternate last state – A configuration selection that instructs the module to convert a user-specified value from the channel fault or program/idle word to the output value when the module enters the fault or program mode.

analog input module – A module that contains circuits that convert analog voltage or current input signals to digital values that can be manipulated by the processor.

attenuation – The reduction in the magnitude of a signal as it passes through a system.

bus connector – A 16-pin male and female connector that provides electrical interconnection between the modules.

channel – Refers to analog input or output interfaces available on the module's terminal block. Each channel is configured for connection to a variable voltage or current input or output device, and has its own data and diagnostic status words.

channel update time – The time required for the module to sample and convert the input signals of one enabled input channel and update the channel data word.

common mode rejection – For analog inputs, the maximum level to which a common mode input voltage appears in the numerical value read by the processor, expressed in dB.

common mode rejection ratio – The ratio of a device's differential voltage gain to common mode voltage gain. Expressed in dB, CMRR is a comparative measure of a device's ability to reject interference caused by a voltage common to its input terminals relative to ground. $CMRR=20 \, Log_{10} \, (V1/V2)$

common mode voltage – For analog inputs, the voltage difference between the negative terminal and analog common during normal differential operation.

common mode voltage range – For analog inputs, the largest voltage difference allowed between either the positive or negative terminal and analog common during normal differential operation.

configuration word – Contains the channel configuration information needed by the module to configure and operate each channel.

D/A Converter– Refers to the digital to analog converter inherent to the output module. The converter produces an analog dc voltage or current signal whose instantaneous magnitude is proportional to the magnitude of a digital value.

dB – (decibel) A logarithmic measure of the ratio of two signal levels.

data echo – The analog value currently being converted by the D/A converter and shown in words 2 and 3 of the output module's input data file. Under normal operating conditions, the data echo value is the same value that is being sent from the bus master to the output module.

data word – A 16-bit integer that represents the value of the analog input or output channel. The channel data word is valid only when the channel is enabled and there are no channel errors. When the channel is disabled the channel data word is cleared (0).

differential operation – The difference in voltage between a channel's positive terminal and negative terminal.

digital filter – A low-pass filter incorporated into the A/D converter. The digital filter provides very steep roll-off above it's cut-off frequency, which provides high frequency noise rejection.

filter – A device that passes a signal or range of signals and eliminates all others.

filter frequency – (-3 dB frequency) The user-selectable frequency.

full scale – The magnitude of voltage or current over which normal operation is permitted.

full scale error – (gain error) The difference in slope between the actual and ideal analog transfer functions.

full scale range – (FSR) The difference between the maximum and minimum specified analog input values.

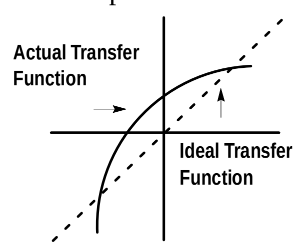
hold last state – A configuration selection that instructs the module to keep the outputs at the last converted value prior to the condition that caused the control system to enter the fault or program mode.

input image – The input from the module to the controller. The input image contains the module data words and status bits.

LSB – (Least Significant Bit) The bit that represents the smallest value within a string of bits. For analog modules, 16-bit, two's complement binary codes are used in the I/O image in the card.

For analog inputs, the LSB is defined as the rightmost bit, bit 0, of the 16-bit field. For analog outputs, the three rightmost bits are not significant, and the LSB is defined as the third bit from the right, bit 2, of the 16-bit field.

linearity error – An analog input or output is composed of a series of voltage or current values corresponding to digital codes. for an ideal analog input or output, the values lie in a straight line spaced by a voltage or current corresponding to 1 LSB. Any deviation of the converted input or actual output from this line is the linearity error of the input or output. The linearity is expressed in percent of full scale input or output. See the variation from the straight line due to linearity error (exaggerated) in the example below.



number of significant bits – The power of two that represents the total number of completely different digital codes an analog signal can be converted into or generated from.

module scan time – same as *module update time*

module update time – For input modules, the time required for the module to sample and convert the input signals of all enabled input channels and make the resulting data values available to the processor. For output modules, the time required for the module to receive the digital code from the processor, convert it to the analog output signal, and send it to the output channel.

multiplexer – An switching system that allows several signals to share a common A/D or D/A converter.

normal mode rejection – (differential mode rejection) A logarithmic measure, in dB, of a device's ability to reject noise signals between or among circuit signal conductors.

normal operating range – Input or output signals are within the configured range. See page 1-2 for a list of input and output types/ranges.

overall accuracy – The worst-case deviation of the output voltage or current from the ideal over the full output range is the overall accuracy. For inputs, the worst-case deviation of the digital representation of the input signal from the ideal over the full input range is the overall accuracy. this is expressed in percent of full scale.

Gain error, offset error, and linearity error all contribute to input and output channel accuracy.

output accuracy – The difference between the actual analog output value and what is expected, when a given digital code is applied to the d/a converter. Expressed as a ± percent of full scale. The error will include gain, offset and drift elements, and is defined at 25°C, and also over the full operating temperature range (0 to 60°C).

output image – The output from the controller to the output module. The output image contains the analog output data.

analog output module – An I/O module that contains circuits that output an analog dc voltage or current signal proportional to a digital value transferred to the module from the processor.

repeatability – The closeness of agreement among repeated measurements of the same variable under the same conditions.

resolution – The smallest detectable change in a measurement, typically expressed in engineering units (e.g. 1 mV) or as a number of bits. For example a 12-bit system has 4096 possible output states. It can therefore measure 1 part in 4096.

status word – Contains status information about the channel's current configuration and operational state. You can use this information in your ladder program to determine whether the channel data word is valid.

step response time – For inputs, this is the time required for the channel data word signal to reach a specified percentage of its expected final value, given a large step change in the input signal.

update time – see “module update time”

Numerics

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